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MAY ★ 1946

INDUSTRIAL
COMMERCIAL
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PUBLIC BUILDINGS

107 — *Journal Section of the American Society of Heating and Ventilating Engineers*

A new classification chart to aid the selection of drying equipment is given this month by W. R. Marshall, Jr.

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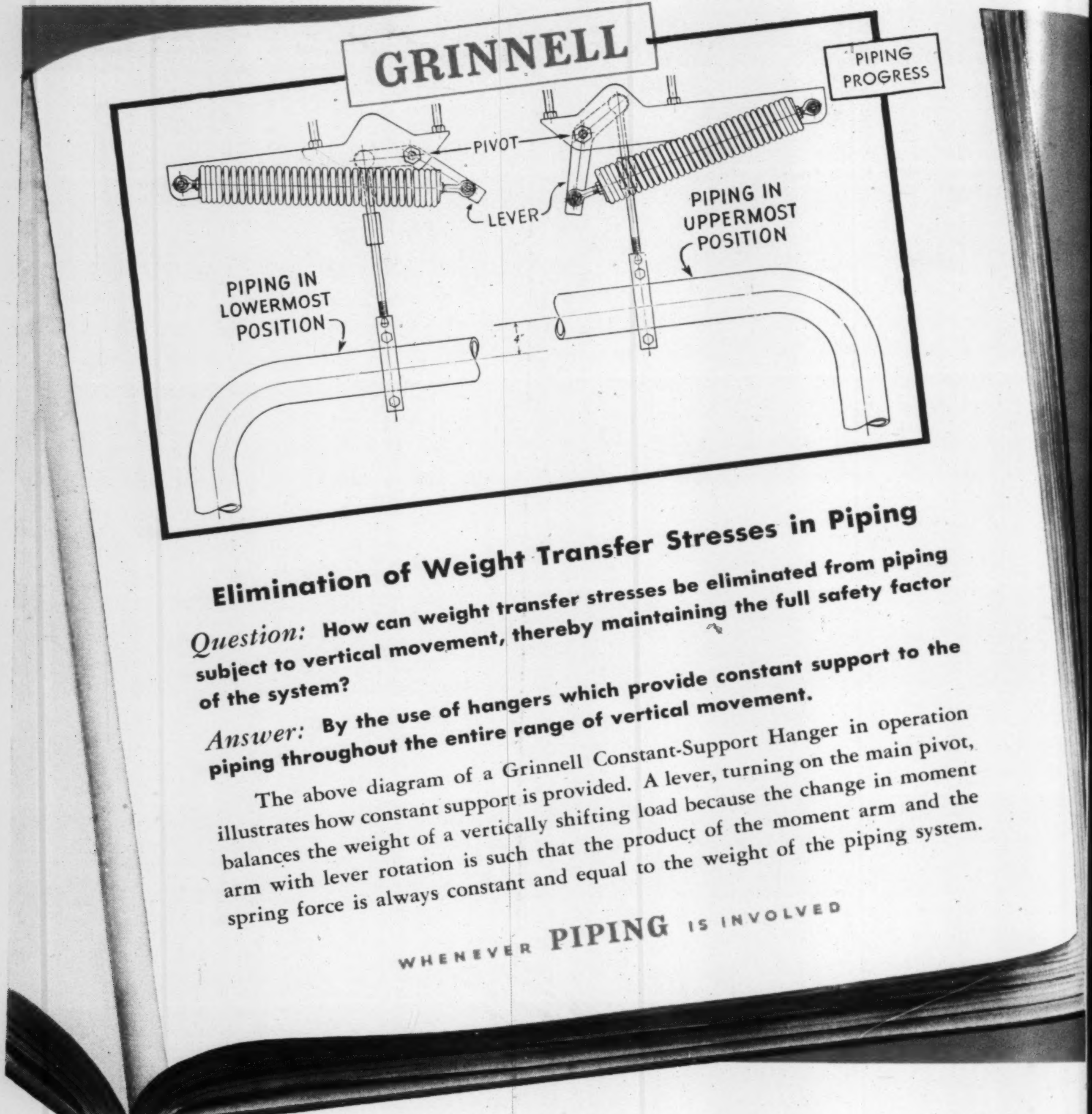

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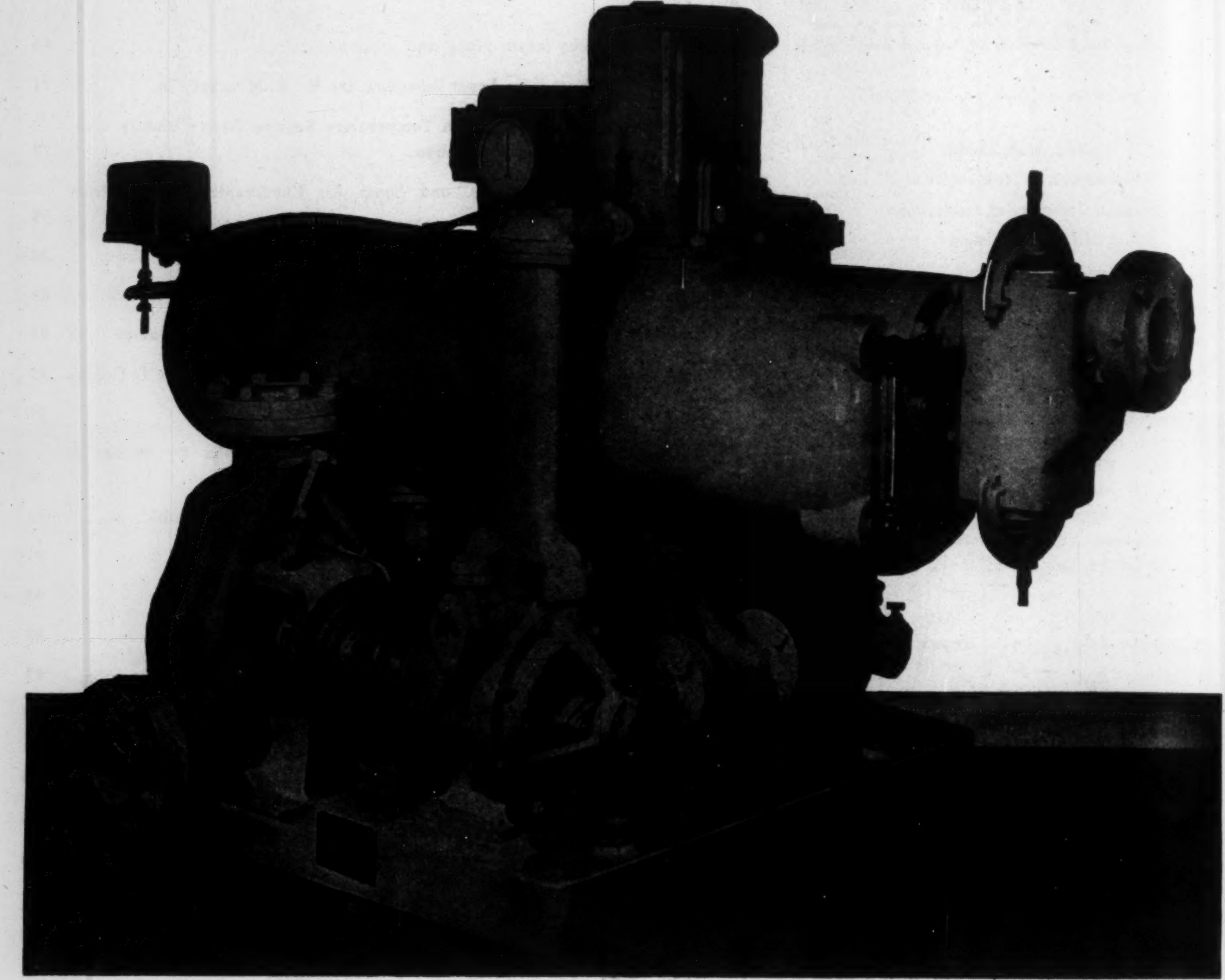
Where Heat Must Not Fai–
Install this SAFE Heating Pump!



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CLASSIFICATION CHART
Aids Dryer Selection

W. R. Marshall, Jr., of the E. I. duPont de Nemours & Co. Engineering Department, Classifies the Types of Drying Equipment Used in Modern Industry to Facilitate Its Proper Choice . . . . Characteristics Are Discussed

LITTLE attention has been given to the problem of classifying the various types of dryers used in modern industry. A satisfactory classification would show that an apparent haphazardness in dryer design and dryer types has in reality some system and reason in spite of the diversification. If a classification can be devised which will assist in making a first choice of several dryers to do a given drying job, and which will also give an immediate overall picture of dryer types based on some fundamental operating characteristic, then such a classification should have practical value. Furthermore, because of the many different types of dryers which have been developed, it is desirable that a classification of these dryers be available for reference when one is considering what types might be suitable for a given problem.

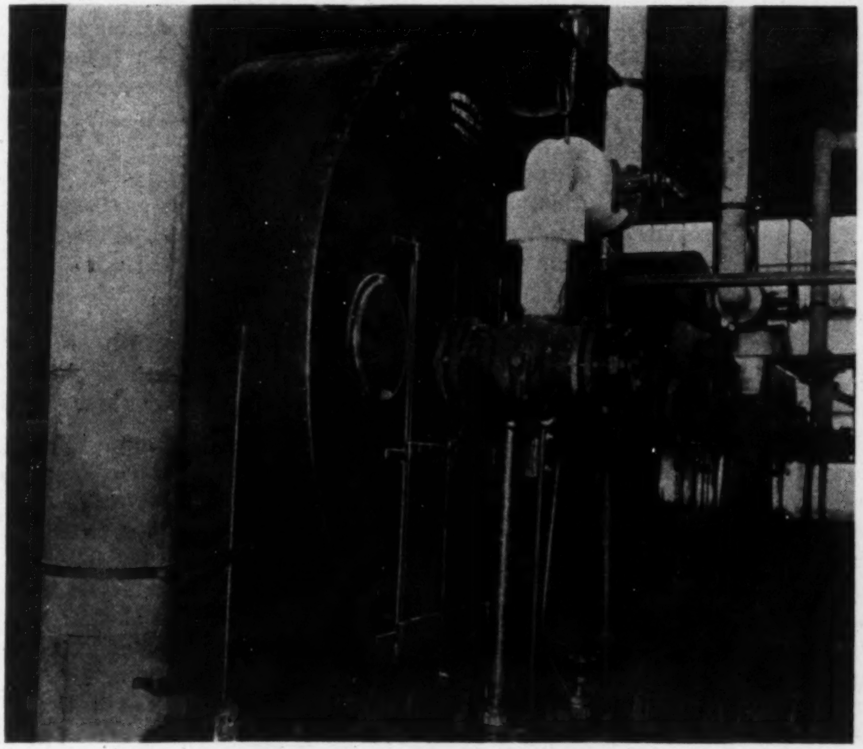
Two methods can be used to classify dryers. One is based on the handling characteristics or physical properties of the material to be dried, and the other is based on the fundamental operating characteristic of the method of transferring heat to evaporate the liquid. Actually, the first method serves better as a classification guide for *selecting* a group of dryers for preliminary consideration when a given material is to be dried, even though it gives no clue as to the reason for or the system behind the multitude of different types of dryers being used. This method might be thought of as a *functional* classification, in which the dryer is considered as a function of the material to be dried. The second method of classification based on heat transfer is independent of the material to be handled, and, therefore, can be considered as a true dryer classification depending only on differences in dryer operation.

The classification of dryers according to materials handled will be considered in connection with the problem of dryer selection, which requires a tabulation or check list for ready reference to the types of dryers which should be considered for a given type of material. However, before such a selection-classification list can be used intelligently, it is obvious that the characteristics of the types of dryers referred to in the list should be well understood. This requires, then, a classification and description of dryers independent of the materials handled, even though it is true that the design of most dryers reflects the attempt to handle as efficiently as possible certain types or classes of materials.

Classification on Basis of Heat Transfer

In making a classification of drying equipment, it is important to agree on a definition of drying. In the following discussion, it is assumed that drying means the removal of a liquid from a solid by *thermal means.* This eliminates mechanical dewatering methods, such as filtering and centrifuging, from consideration. However, it makes no distinction between evaporators and dryers. No confusion should arise here because evaporators generally are used to concentrate a solution by boiling and at the same time maintain a fluid

Indirect dryers, 6 ft in diameter by 50 ft long, at a distillery for producing dried grains, showing some of the piping required. (Photo courtesy General American Transportation Corp., which also furnished photo shown on front cover)



mass, while dryers generally remove all or enough moisture to give the material a definite, solid structure. Temperatures of the liquid during drying are usually less than its boiling point. Furthermore, dryers and evaporators differ generically in physical form as well as in operation.

In the chart shown on p. 75, a classification of dryers has been made on the primary basis of the method of transferring heat to the wet material. A secondary basis of distinction utilizes continuous vs. batch operation. The chart can be used first to determine how heat is transferred in a given dryer, and second as a reference to consider all possible types of dryers for a given problem. The method of heat transfer and mode of operation, batch vs. continuous, have importance with regard to subsequent operating characteristics and details. Some of the outstanding characteristics of the types of dryers given in the classification chart are discussed below.

Direct Dryers

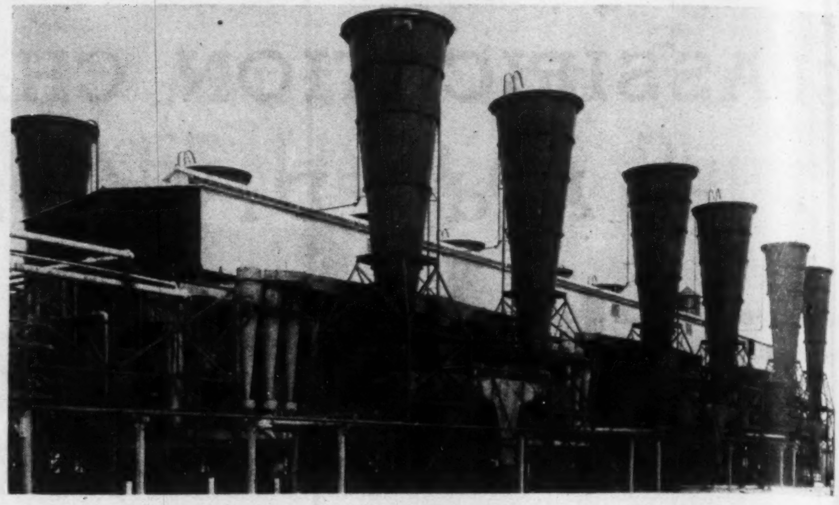
According to the chart, all dryers in which the evaporated liquid is carried away by the heating medium are termed *direct* dryers. The general operating characteristics of direct dryers may be enumerated as follows:

1) Drying is accomplished by convection heat transfer between the wet solid and a hot gas, the latter removing the vaporized liquid as well as supplying the heat for evaporation.

2) The heating medium may be steam heated air, gases of combustion, a heated inert atmosphere (such as nitrogen), or a superheated vapor (such as steam).

3) Drying temperatures may range from prevailing atmospheric temperatures to 1400 F, the limiting temperature for most common metals of construction.

4) At drying temperatures below the boiling point of the liquid being removed, the vapor content of this liquid in the drying gas is important in determining the rate of drying and the final liquid content of the solid. When drying temperatures are *above* the boiling point throughout the process, the vapor content of the gas or air in general will have only a slight or no retarding effect on the drying rate or final moisture content. Thus, superheated vapors of the liquid being removed could be used for transferring the heat and removing the evaporated vapors.



Spray dryers installed at a magnesium plant. This unit consists of 24 spray chambers, 96 dust collectors, 12 washers and furnaces, connecting duct work, piping, wiring, etc. The spray chambers are in two rows of 12 each under the housing. An operating passageway extends through the center of the housing between the two rows of chambers. (Photo courtesy Bowen Engineering, Inc.)

5) For low temperature drying, it is not uncommon to employ an air drying or dehumidification unit to reduce the humidity of the drying air to some constant value at the dryer entrance. Such a system may be very essential during the summer months when humidities are likely to be excessively high.

6) In general, the lower the final moisture content of the product from a direct dryer, the more inefficient will be the operation of the dryer, and more fuel per pound of water evaporated will be consumed. Likewise, the investment cost will increase markedly.

7) The efficiency of direct dryers will increase with an increase in the inlet temperature of the drying gas when the exhaust temperature remains fixed.

Characteristics of Direct Continuous Dryers

In general, direct dryers which are designed for continuous operation should handle production capacities above 100 lb per hr of dry product. In some cases, continuous dryers may handle as low as 50 lb per hr *when the evaporation load is high;* i.e., when initial moisture contents are on the order of 2 lb water per lb of dry solid or higher.

It is also generally true that continuous direct dryers can be operated more efficiently than batch direct dryers, because the former can take advantage of the directional properties of the flowing streams of gas and solid in a manner which will give the highest overall temperature difference between gas and solid. Thus, a solid which is temperature sensitive can be made to contact relatively cool gases by the proper arrangement of air flow—in this case flow parallel to the direction of motion of the solid. If the flow of gases and solids can be made to oppose each other, i.e., countercurrent flow, then the most efficient operation for *given terminal temperatures* is obtained. It is generally true that the most economical drying is accomplished at the highest possible inlet gas temperature for a given exhaust gas temperature. This can be seen from the following definition of overall efficiency for a continuous direct dryer:

$$\text{Per cent efficiency} = \frac{\text{Heat used for evaporation}}{\text{Total heat supplied}} \times 100$$

which can be interpreted in terms of temperatures as

$$\eta = 100 \left(\frac{t_1 - t_2}{t_1 - t_a} \right) \ldots\ldots\ldots [1]$$

where η = overall dryer efficiency, per cent; t_1 = inlet gas temperature; t_2 = reduced temperature caused by *evaporation* only; and t_a = temperature of air entering main heaters.

In case the sensible heat picked up by the solid is essential to the process, then t_2 should take this fact into account. The above definition holds where there is no reheating done within the dryer, and where $(t_1 - t_2)$ represents the temperature drop suffered by the gases from loss of useful heat only in the drying operation.

Equation 1 is applicable to direct rotary dryers, tunnel dryers with no reheat sections, spray dryers, pneumatic conveying dryers, direct continuous sheeting dryers, and other direct types in which the air passes through without reheating. It is apparent that if t_2 is maintained constant and t_1 increased, then η increases. Of course, in order that this may be true at a constant evaporative load, the air rate must be decreased accordingly, which permits reduced power consumption. It should also be noted that increasing t_a increases η, which argues for recirculation of part of the exhaust gases when they are not too near saturation, and when such recirculation does not decrease the drying rate with a resultant increase in dryer size which would offset any gain in fuel saving.

In convection dryers it is generally theoretically impossible to obtain 100 per cent efficiency on the basis of the definition given by equation 1. This may be realized with the aid of a section of a humidity chart, as shown in Fig. 1. If t_a represents the condition of the gas prior to heating and entering the dryer, then the line *AB*, or $(t_1 — t_a)$, is proportional to the heat input to the drying gases. Now, if drying were to proceed in such a manner that all the sensible heat in the gas is used for evaporation only, i.e., adiabatic operation, then the air temperature would follow the path *BC*, a line of adiabatic saturation, and the best heat utilization possible would be if the temperature of the gas reached t_w, the adiabatic saturation temperature, which is generally greater than t_a. Should this occur, saturation of the gas would result.

Actually, the air temperature follows some path such as *BD*, which shows a deviation from a line of adiabatic saturation, and indicates heat utilization for purposes other than evaporation. The change in air conditions due to evaporation only may be represented arbitrarily by the line segment *BE*. It is apparent that an expression for dryer *evaporative* efficiency may now be written as

$$\eta_e = \frac{BE}{BC} \times 100 = \frac{t_1 - t_2}{t_1 - t_w} \times 100 \quad \ldots [2]$$

where η_e is termed evaporative efficiency to distinguish from η, the overall efficiency, in equation 1. The various temperatures in equation 2 are shown in Fig. 1. Equation 2 compares the evaporation actually obtained with that which is theoretically possible for a given set of conditions. The evaporative efficiency is affected by dryer design, type of material dried, and final moisture content.

The various modifications to and implication of Fig. 1 if recirculation is used for higher values of t_a and t_1, etc., are apparent, and the reader can amplify the diagram to meet such other conditions as may be desired.

In general, overall operating costs of continuous direct dryers expressed on a basis of cost per lb of dry product are lower than similar costs for batch direct dryers, primarily because of lower labor and fuel costs and higher production rates. A range of operating costs for direct continuous dryers might be from $0.0005 to $0.025 per lb of dry product. These figures include only labor, power, fuel and maintenance. Depreciation and overhead are functions of the particular plant involved.

Characteristics of Direct Batch Dryers

Direct batch dryers are generally used only for low production rates or for certain cases where special handling of a high cost product is required. These dryers are characterized by long drying times (6 to 40 hr is a representative range), and unsteady-state operation in which the drying conditions of air temperature, humidity, material temperature, and moisture content all change continually with time at a given position in the dryer. Direct batch dryers generally do not dry uniformly unless they are very carefully designed from the standpoint of tray spacing and uniformity of air flow. Even then there is no assurance that they will be operated properly with respect to tray loading. It is not uncommon to find plant operated tray dryers with one or more of the trays so overloaded that no air can pass over them. It is also not uncommon to find tray dryers in which air flow is so nonuniform because of improper design that it actually is flowing in a reverse direction across the trays at the top.

The economics of this class of dryers is best characterized by high fuel costs and high labor costs which contribute to produce a generally high overall operating cost per pound of dry product. Fuel consumption in some cases may run

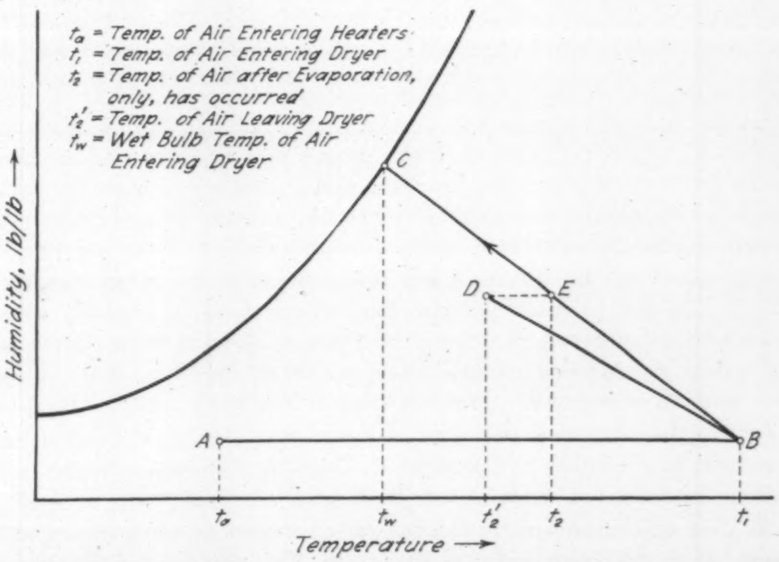

t_a = Temp. of Air Entering Heaters
t_1 = Temp. of Air Entering Dryer
t_2 = Temp. of Air after Evaporation, only, has occurred
t_2' = Temp. of Air Leaving Dryer
t_w = Wet Bulb Temp. of Air Entering Dryer
Humidity, lb/lb →
Temperature →
A
B
C
D
E
t_a
t_w
t_2'
t_2
t_1

Fig. 1—Humidity Chart to Illustrate Temperature Relationships in Direct Dryers with no Reheat Sections

as high as 6 to 8 lb of steam per lb of water evaporated. This ratio seldom is less than 2.5, and increases as the desired final moisture content is decreased.

The batch through-circulation dryer represents a distinct improvement in direct batch dryers. This type gives higher drying rates than cross-circulation tray dryers, and hence permits the batchwise handling of larger production rates, if so desired. Its use is restricted to those materials which are or can be made permeable to *through-circulation* of air. In some cases this may require the use of preforming equipment.

Indirect Dryers

According to the dryer classification chart, indirect dryers differ from direct dryers with respect to heat transfer and vapor removal. The general operating characteristics of indirect dryers may be listed as follows:

1) Drying results from the transfer of heat to the wet material by conduction through a solid retaining wall, usually metallic. The source of heat on the other side of the retaining wall is generally condensing steam, but may also be hot water, gases of combustion, molten heat transfer salts, hot oil, electric heat, etc.

2) Drying temperatures of the surfaces of contact may range from below freezing in the case of frozen state dryers to 1000 F in the case of indirect rotary dryers using heat from combustion gases.

3) Indirect dryers are especially suited to drying under reduced pressures and with inert atmospheres. It follows that where recoverable solvents other than water are to be evaporated from a solid, indirect dryers are best adapted to this requirement. They permit not only the recovery of the solvent but also the introduction of inert gases to eliminate the occurrence of explosive mixtures or oxidation of easily decomposed materials.

4) Indirect dryers using condensing steam are generally the most economical of all types from the standpoint of heat consumption. This is because they furnish heat only in accordance with the demand made by the material being dried. However, as in the case of direct dryers, the efficiency of indirect dryers is markedly reduced as the final moisture content is lowered.

5) The problems of dust recovery and the drying of dusty materials can be handled most satisfactorily in indirect dryers.

6) Temperature sensitive materials cannot usually be dried economically or satisfactorily in indirect dryers using steam. Usually, hot water heat and vacuum are required for such materials.

7) The operation of indirect dryers is frequently characterized by some method of agitation to improve the contact between the hot metal surface and wet material, as well as to effect a continual change in wet material at the hot surface. The nature of this contact determines the overall drying rate of indirect dryers. Heavy, granular materials generally give higher heat transfer coefficients of contact than fluffy, bulk solids. It is also believed that the surface temperature affects the coefficient of heat transfer.

Characteristics of Indirect Continuous Dryers

Indirect continuous dryers, in general, are probably the most economical to operate of all types of dryers. Labor costs are no greater than for direct continuous dryers, and in general fuel costs will be lower. It is not unusual to obtain efficiencies of 70-80 per cent on steam tube rotary dryers, for example, while in drum drying operations where the desired final moisture content is not too low, steam consumptions as low as 1.2 lb per lb of water evaporated can be obtained. It should be stressed again that—as a general rule for all types of dryers—efficiency of heat utilization is markedly affected by the final moisture content to which the material is to be dried. Thus, it would not be unusual to find that the efficiency of a dryer is reduced from 70 per cent to 50 per cent by changing the final moisture content specifications from 1 per cent to 0.5 per cent.

Where a capacity comparison between a direct and indirect dryer is justified, it is generally true that an indirect dryer has more capacity than a direct dryer of the same size at comparable temperatures of operation. Thus, for example, a steam tube rotary dryer will have from two to three times the capacity of the same size direct rotary for the same temperature of the heating medium. Such a comparison presupposes, of course, that each type of dryer can handle the material in question equally satisfactorily.

Indirect continuous dryers can frequently be operated at pressures less than atmospheric, and where good seals at the charging and discharging points can be made, negative pressures of 27-28 in. of mercury can be maintained during continuous operation. The obvious advantage of this feature is that continuous drying can be performed in conjunction with solvent removal and solvent recovery. Continuous drying with solvent recovery is a field which warrants development and research because, although recovery of solvent vapors from drying is generally practical

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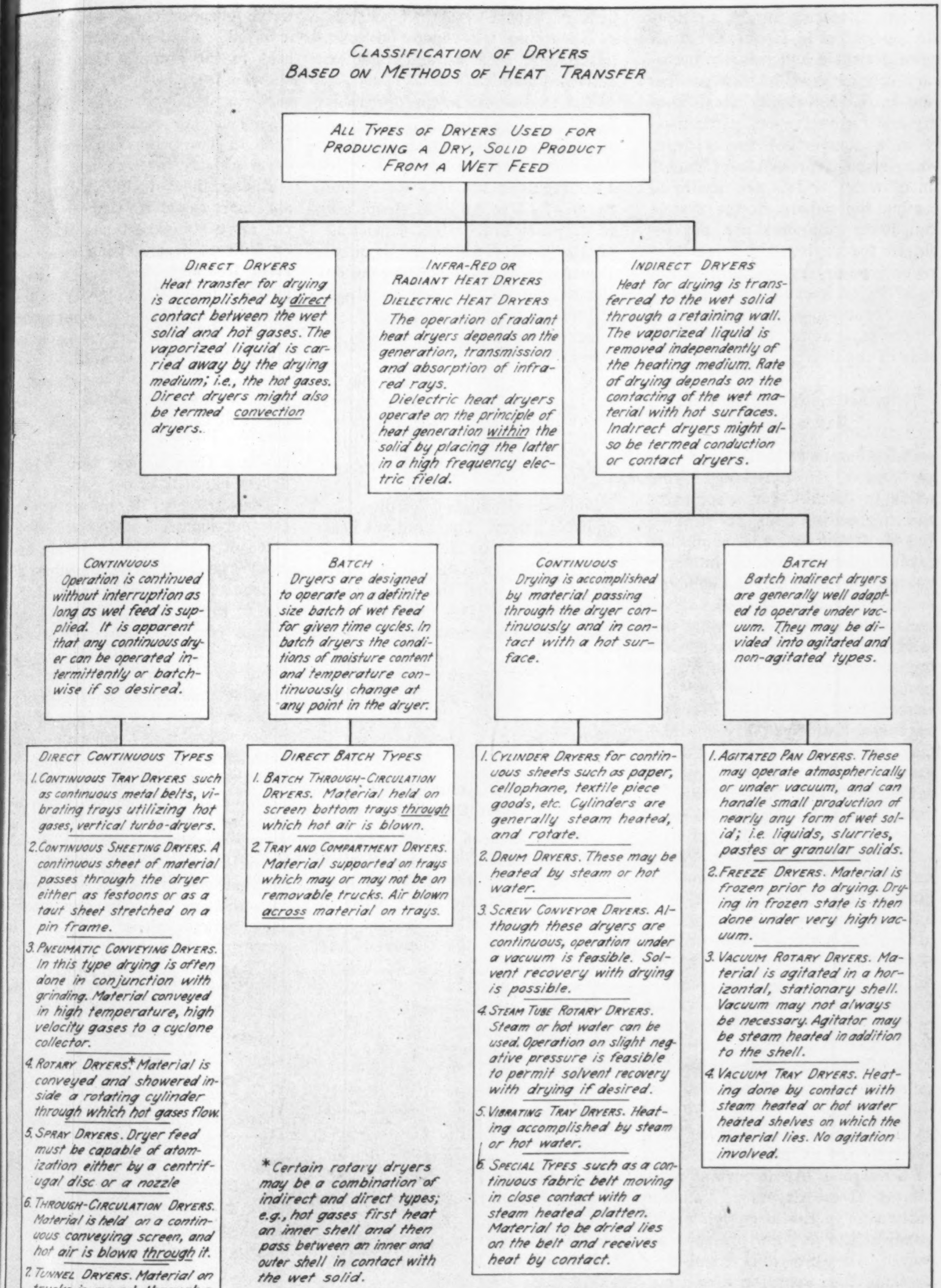
DRYING'S A SUBJECT that involves piping and heating and air conditioning, for heat must usually be conveyed to and away from the drying equipment by means of piping or ductwork, and the effect of the drying process on the overall plant heating, ventilating, and air conditioning systems—and on the plant piping services—must be given consideration. . . . In this practical article, the author gives a general, overall picture of basic differences among the various types of dryers commonly used today. A complete, detailed description of each type has not been given or even attempted; rather, an attempt has been made to show that dryers can be classified in a logical manner according to certain basic differences in operating characteristics. This classification is based on the different methods of transferring heat and removing the evaporated liquid. The operating characteristics of the dryers in each group of the classification are discussed, as are costs. The problem of relating the various dryers to the types of materials each one is best suited to handle has been reserved for subsequent discussion of the problem of selection.



CLASSIFICATION OF DRYERS
BASED ON METHODS OF HEAT TRANSFER

ALL TYPES OF DRYERS USED FOR PRODUCING A DRY, SOLID PRODUCT FROM A WET FEED

DIRECT DRYERS

Heat transfer for drying is accomplished by direct contact between the wet solid and hot gases. The vaporized liquid is carried away by the drying medium; i.e., the hot gases. Direct dryers might also be termed convection dryers.

INFRA-RED OR RADIANT HEAT DRYERS

DIELECTRIC HEAT DRYERS

The operation of radiant heat dryers depends on the generation, transmission and absorption of infrared rays.

Dielectric heat dryers operate on the principle of heat generation within the solid by placing the latter in a high frequency electric field.

INDIRECT DRYERS

Heat for drying is transferred to the wet solid through a retaining wall. The vaporized liquid is removed independently of the heating medium. Rate of drying depends on the contacting of the wet material with hot surfaces. Indirect dryers might also be termed conduction or contact dryers.

CONTINUOUS

Operation is continued without interruption as long as wet feed is supplied. It is apparent that any continuous dryer can be operated intermittently or batchwise if so desired.

BATCH

Dryers are designed to operate on a definite size batch of wet feed for given time cycles. In batch dryers the conditions of moisture content and temperature continuously change at any point in the dryer.

CONTINUOUS

Drying is accomplished by material passing through the dryer continuously and in contact with a hot surface.

BATCH

Batch indirect dryers are generally well adapted to operate under vacuum. They may be divided into agitated and non-agitated types.

DIRECT CONTINUOUS TYPES

1. CONTINUOUS TRAY DRYERS such as continuous metal belts, vibrating trays utilizing hot gases, vertical turbo-dryers.
2. CONTINUOUS SHEETING DRYERS. A continuous sheet of material passes through the dryer either as festoons or as a taut sheet stretched on a pin frame.
3. PNEUMATIC CONVEYING DRYERS. In this type drying is often done in conjunction with grinding. Material conveyed in high temperature, high velocity gases to a cyclone collector.
4. ROTARY DRYERS.* Material is conveyed and showered inside a rotating cylinder through which hot gases flow.
5. SPRAY DRYERS. Dryer feed must be capable of atomization either by a centrifugal disc or a nozzle
6. THROUGH-CIRCULATION DRYERS. Material is held on a continuous conveying screen, and hot air is blown through it.
7. TUNNEL DRYERS. Material on trucks is moved through a tunnel in contact with hot gases.

DIRECT BATCH TYPES

1. BATCH THROUGH-CIRCULATION DRYERS. Material held on screen bottom trays through which hot air is blown.
2. TRAY AND COMPARTMENT DRYERS. Material supported on trays which may or may not be on removable trucks. Air blown across material on trays.

*Certain rotary dryers may be a combination of indirect and direct types; e.g., hot gases first heat an inner shell and then pass between an inner and outer shell in contact with the wet solid.

1. CYLINDER DRYERS for continuous sheets such as paper, cellophane, textile piece goods, etc. Cylinders are generally steam heated, and rotate.
2. DRUM DRYERS. These may be heated by steam or hot water.
3. SCREW CONVEYOR DRYERS. Although these dryers are continuous, operation under a vacuum is feasible. Solvent recovery with drying is possible.
4. STEAM TUBE ROTARY DRYERS. Steam or hot water can be used. Operation on slight negative pressure is feasible to permit solvent recovery with drying if desired.
5. VIBRATING TRAY DRYERS. Heating accomplished by steam or hot water.
6. SPECIAL TYPES such as a continuous fabric belt moving in close contact with a steam heated platten. Material to be dried lies on the belt and receives heat by contact.

1. AGITATED PAN DRYERS. These may operate atmospherically or under vacuum, and can handle small production of nearly any form of wet solid; i.e. liquids, slurries, pastes or granular solids.
2. FREEZE DRYERS. Material is frozen prior to drying. Drying in frozen state is then done under very high vacuum.
3. VACUUM ROTARY DRYERS. Material is agitated in a horizontal, stationary shell. Vacuum may not always be necessary. Agitator may be steam heated in addition to the shell.
4. VACUUM TRAY DRYERS. Heating done by contact with steam heated or hot water heated shelves on which the material lies. No agitation involved.

for batch indirect dryers, continuous operation is frequently much more desirable and actually necessary in some cases of high production rates. It is quite feasible to dry and recover vapors continuously in a steam tube rotary dryer when reduced pressures of only 1 in. of water or less are needed to confine the vapors in the system and lower pressures are not required for drying. In screw conveyor type dryers, vacuums as low as 27 in. of mercury can be maintained continuously with the use of proper seals at the inlet and outlet ends of the dryer.

Characteristics of Indirect Batch Dryers

Batch dryers of the indirect type are suited primarily for drying solids in batches, for evaporating and drying solutions or slurries, and for drying under vacuum. Such dryers may be divided into two groups, one in which the solid remains stationary throughout the cycle, and the other in which the solid is continuously agitated during the drying cycle. The former group is best typified by the vacuum tray dryer, and the second by the agitated pan dryer, which may or may not operate under vacuum. Vacuum tray dryers are suited best for small batches of dusty materials which would cause serious dust losses if agitation were used during drying. Some materials, on the other hand, require a very vigorous agitation or milling during drying followed by a high vacuum in order to produce certain desired properties in the final product. The power requirements for milling down to dryness may be as high as several hundred horsepower for certain materials. This power obviously reflects a grinding action during drying.

In the case of drying materials in the frozen state, relatively high vacuums are utilized, on the order of 5 microns. An important problem in freeze dryers is handling satisfactorily the large volumes of vapor at the very low pressures involved. One procedure consists of freezing the vapors on a cold surface which is continuously kept free of ice by a rotating scraper, the ice falling into a receiver which is discharged after the vacuum has been broken. Another method consists of adsorbing the vapors on solid adsorbents, such as silica gel or activated alumina.

The major cost in the operation of batch indirect dryers is labor for charging and discharging the dryers, and in many cases for cleanup. Fuel requirements may lie in the range of 1.5 to 3.0 lb of steam per lb of water evaporated, depending on the desired degree of dryness. Power requirements will depend on the degree of agitation required, the nature of the material, and—if vacuum is used—the degree of evacuation.

It will be noted that the classification chart does not include radiant heat or dielectric heat dryers with either direct or indirect dryers. This is because neither of these types completely satisfies the definitions established for direct or indirect dryers. Thus, radiant heat dryers cannot be classed as direct dryers, since (although there is direct contact with the radiant energy which supplies the heat) the vapors are not removed by the heating medium. On the other hand, radiant heat dryers do not satisfy the criteria set up for indirect dryers, and hence it is logical to place them in a separate subdivision.

Radiant Heat and Dielectric Heat Dryers

Dielectric heat dryers are peculiar in that their operation is typified by the *generation* of heat inside the material being dried so that it is not at all unlikely the heat will flow from the center of the solid outward because of higher temperatures in the interior.

Dryers which operate on the basis of radiant energy are generally continuous dryers. They are best suited for drying materials in which the thickness of the wet material is quite small, not greater than about 1/8 in., for example. Contrary to prevailing opinion, the infrared rays do not penetrate the solid material to any appreciable or significant depth.

Radiant heat may be generated electrically or by refractory materials heated to incandescence by the combustion of gas. The greatest application of radiant heat dryers has been to the drying and baking of paint films and enamels in which water evaporation is not usually involved. Application of radiant heat to the evaporation of water may be feasible to thin materials such as textiles, or it may be feasible as an auxiliary source of heat to boost the capacity of a dryer already in operation.

Radiant heat drying is considerably more expensive than drying in the more standard types of direct or indirect dryers using steam or other common fuels of a comparable cost. If electricity is the source of radiation in radiant heat dryers, then fuel costs may be as much as 10 times those for direct or indirect dryers, while if gas is the source of the radiant heat, the cost will be about four times. The maximum efficiency which can be expected from electric radiant heat dryers is about 30 per cent.

Dielectric heat dryers are still in the development state, and their place of application to drying has not yet been properly determined. It is true at the present time that the cost of this method is excessive and cannot compete with conventional methods for established drying problems; however, it is entirely possible that certain special drying problems may be solved best by dielectric heating to give a product sufficiently improved in quality to stand the high drying cost. In general, dielectric drying will find possible advantage in the drying of large, massive objects which require scores of hours to dry by conventional means—for example, rayon cakes, wooden gun stocks, large ceramic pieces.

JOHN L. LEWIS TOOK US TOO SERIOUSLY

We've been running a number of articles in Heating, Piping & Air Conditioning lately about the importance of smoke abatement and methods of eliminating excessive air pollution, but we certainly didn't mean to imply that coal shouldn't even be mined in order to prevent dirty air in cities. There are types of city ordinances, and methods of design, installation, operation, and maintenance of fuel-using equipment—many of which have been pointed out in these articles—that can do the job a bit more simply.

Pipe Wall Thicknesses for High Temperature Service Aren't Unduly Conservative

By Arthur McCutchan, Engineering Division, The Detroit Edison Co.

THE writer sympathizes with Otis W. Page's objective—as discussed in his article entitled Pipe Wall Thickness Based on Total Combined Stress, in the March issue of Heating, Piping & Air Conditioning—of securing pipe wall thicknesses better proportioned to the services involved. There are, however, a number of points in his article which are not in accord with the present writer's view of the problem.

Contrary to Mr. Page's conclusion, the writer believes that the bursting or hoop stress *is* the critical stress in considering pipe wall thickness. The bending stress due to restraint of thermal elongation is capable of relaxation and the writer has not found evidence of creep failure under relaxation loading. The only adverse effect of bending stress at high temperatures caused by thermal elongation that has been related to pipe failure is the possible accelerating effect on radial creep of the side of the pipe under compressive longitudinal stress. Difficulties due to excessive bending moments causing leaks at bolted joints and excessive thrusts on equipment are outside the scope of this particular discussion.

Mr. Page evidently has overlooked the chapter on expansion and flexibility in the American Standards Association Code for Pressure Piping, in his statement that direct recognition of bending stresses was not made in the codes.

Factor of Safety

Mr. Page's use of the term "factor of safety" when applied to pipe used at temperatures of 850 F and higher is not in accord with the known behaviour of steels under conditions where creep is a factor. The allowable working stresses given in the ASME boiler code and in the ASA piping code at 650 F are one-fifth of the tensile strength at room temperature, not one-fourth or one-eighth of the yield strength as stated by Mr. Page. At 900 F the allowable stresses in the boiler code and in the power piping section of the piping code are understood to be approximately 80 per cent of the stress producing an elongation rate of 1 per cent in 100,000 hr. [See discussion of the 1942 Code for Pressure Piping, section 3, Heating, Piping & Air Conditioning, March 1942.] There is no very good basis for arriving at any "factor of safety" under the latter condition and certainly the material would not support a stress at 900 F of four times the 10,000 psi permitted for carbon-moly at that temperature for more than a few hours. Therefore, it would not seem to be permissible to say that a factor of safety of four exists with pipe designed on the basis of code formulas for 850 F and higher.

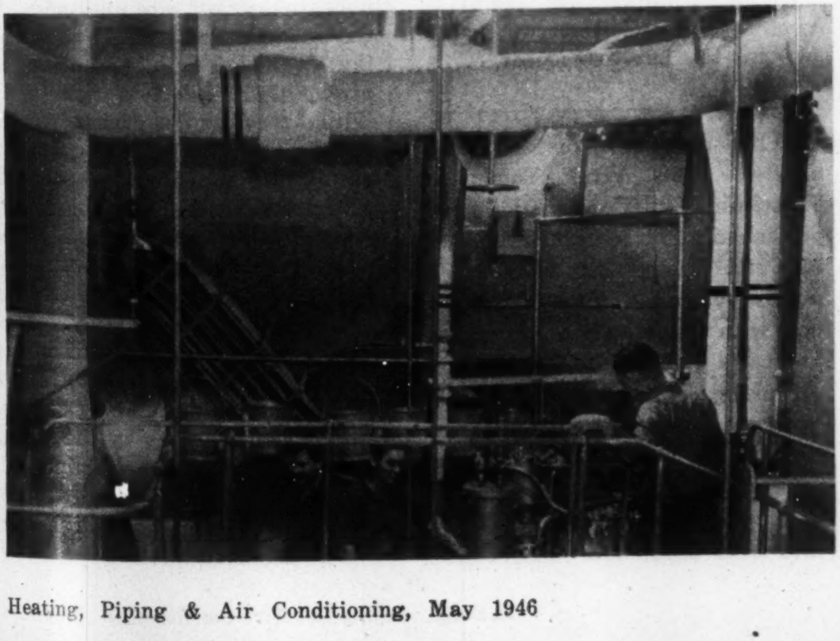
As a matter of fact, on the basis of total permissible elongation before failure, present allowable stresses for materials such as carbon-moly, which tend to rupture after prolonged loading with rather limited total extension, may not prove to be at all conservative. Unfortunately, there is a tendency to assume that a pipe which has been in service for 10 years or so has some way proved itself, rather than to assume that it may have increased in diameter about one-half of its permissible total extension. Efforts to measure diametral increases of pipe in service have not been too successful, but reasonable correlation with predictions from laboratory creep data have been obtained in a few instances.

May Prove Dangerous

The writer does not wish to be an alarmist, but believes that cutting the pipe wall thickness too

The bursting or hoop stress is critical

Acme



thin on the basis that present stresses should be higher or that bending stresses can in some manner be combined with bursting stresses to result in a reduction in wall thickness, may prove to be dangerous where temperatures above about 850 F are involved.

This does not mean that present thicknesses—particularly those required for naval and marine piping—may not be advantageously reduced in many cases. The requirement that the next commercial thickness shall be selected for bends to compensate for thinning of the outside wall is typical of arbitrary rules that may call for using unnecessary wall thickness.

Mr. Page appears to be correct in his discussion of the effect of pipe wall thickness on bending stress, since with minor exceptions the two are independent. The permissible bending stress, however, is determined according to the piping code by subtracting the longitudinal stress due to internal pressure from the total combined stress which is three-fourths of the sum of the allowable stress (*S* value) at 650 F and at 900 F. Heavier pipe, therefore, does give an increase in permissible bending stress in straight pipe according to this code, but the differences are not particularly significant for any probable differences in pipe thickness that would be selected for a given service. The advantage of using heavier short radius bends, or welding elbows, as a means of reducing the value of the stress multiplication factor β should, of course, be recognized in checking the flexibility of piping layouts.

Corrosion Allowances

Mr. Page's criticism of the corrosion allowances required by the piping code for steam and oil piping appears to be based on a misconception of the services involved. Oil piping within power plants is assigned the same corrosion allowance and allowable stress values as for steam piping. It is only oil piping systems used in the production, transmission, and refining of petroleum to which the lesser corrosion allowance is applicable. It should be noted that allowable working stresses in section 3 of the piping code, which covers oil piping systems, are about 25 per cent higher than permitted in section 1 on power piping. The resulting pipe wall thicknesses for a given pressure-temperature condition in refinery piping consequently are much less than would be required for an oil line within a power plant. These differences do not imply that oil piping requirements in the piping code are not entirely adequate for the different services required of refinery piping.

The *C* factor has never been mentioned in code discussions as having any connection with expansion stresses and in the opinion of the writer its effect is almost negligible in that connection.

Permanent Set of Piping

It is not clear what Mr. Page has in mind in the statement that "It is not surprising then to read of the permanent set which a piping system takes when first put into service." If this statement refers to the loss of prespring which is often observed when a joint is unbolted after a period of service, then it seems desirable to the writer to point out that this apparent set is more properly attributable to swiveling at joints during erection or inability to secure the necessary accuracy in lining up the various pipe elements. It is now generally recognized that it is not due to excessive bending stresses, as the latter naturally result in an increase in the apparent amount of prespring. Relaxation of excessive bending stresses at high temperatures and prespringing both reduce the stresses carried by the material at operating temperatures; therefore, their effect is additive—rather than subtractive, as has sometimes been assumed. A full discussion of this point was given in an ASME paper on Significance of and Suggested Limits for the Stress of Pipe Lines Due to the Combined Effect of Pressure and Expansion, by D. B. Rossheim and A. R. C. Markl, Transactions, ASME, Vol. 62, No. 5, July 1940.

Reducing thickness may be dangerous

IN THIS discussion of the article entitled Pipe Wall Thickness Based on Total Combined Stress, published in the March HPAC, Mr. McCutchan says that there are a number of points in the March article with which he is not in agreement. He points out that a method of taking bending stresses into account exists in the Code for Pressure Piping, and he states that present pipe wall thicknesses for service at temperatures of 850 F and over aren't too conservative.

Mr. Page's conclusion that present rules have been inadequate for low pressures where "even normal bends were used" is not supported by any piping failures that have come to the writer's attention. Mr. Page's proposed thicknesses for high pressures chance to line up quite well with those based on the piping code, so would seem to give no basis for criticism of that code. The greater thicknesses required by the Coast Guard and American Bureau of Shipping are noteworthy and are in line with the writer's finding that such piping is heavier than comparable piping in central station work. While good and sufficient reasons for the use of heavier pipe for ship's piping doubtless can be given, the writer's opinion is that less difficulty with bolted joints, excessive thrusts, etc., would result from the use of lighter pipe with no sacrifice in safety.

The purpose of this discussion has been to point out that a method of taking bending stresses into account exists in the piping code and that present pipe wall thicknesses for service at temperatures of 850 F and higher are not unduly conservative.

Stokers, Conversion Burners and Some Air Conditioning Exempt from Housing Order

SPECIFIC EXEMPTIONS of certain articles from the restrictions of the construction control order were announced May 2 by the Civilian Production Administration. These items were included in supplement 1 to Veterans' Housing Program Order 1.

Supplement 1 also lists the kinds of fixtures and mechanical equipment whose installation, above the small job cost allowances in the construction order, requires authorization from CPA. In addition it explains in detail provisions of the order applying to installation of fixtures, mechanical equipment, and other equipment.

Under the building control order (VHP-1) authorization is required for—among other things—the installation of fixtures and "mechanical equipment" and alteration of structures, with some exceptions. The order does not restrict the installation of machinery and equipment other than mechanical equipment. Supplement 1 states that the articles listed below [among others] are never considered to be fixtures or mechanical equipment. Therefore, these articles may be installed without regard to the provisions of the order, as long as no alteration to the building is required (such as installing foundations, putting up partitions, and the like):

Air conditioning equipment where required to provide humidity or temperature control for industrial processing and self-contained individual units with no duct systems.

Automatic fire protection sprinkler systems.

Control or testing equipment used for industrial or utility purposes or in a laboratory or hospital.

Conversion oil or gas burners.

Power generating or transmitting equipment such as boilers, generators, and transformers (except where the primary purpose of the equipment is to provide electricity or steam for lighting or heating the building in which they are installed).

Refrigeration equipment, such as compressors, in a cold storage warehouse or a frozen food locker plant.

Refrigerators (except where built as an integral part of the building).

Stokers.

Storm windows, storm doors, screens and awnings.

Other processing machinery and equipment.

Other machinery and equipment installed to provide a special service in a structure and not installed merely to operate the structure.

However, the supplement explains that any alteration to a building or other structure covered by the order, in connection with the installation of exempt machinery or equipment, is restricted. For example, if a foundation is built inside a building to receive the equipment, or if partitions or new walls are installed to separate a machine from the rest of a plant, the job would require authorization unless the cost of the alteration work comes within the small job allowance for that type of building.

Restrictions in the construction control order do not apply to the installation of any kind of equipment, including mechanical equipment, outside of and not attached to a building. Supplement 1 to VHP-1 explains that this exemption applies even if a foundation must be built for the piece of equipment and even if the equipment is connected to a building by pipes or pipe lines, wires, or the like.

Veterans' Housing Program Order 1 states that the cost of mechanical equipment or fixtures must be included in the total estimated cost of an installation or relocation job, to determine if the job comes within the small job allowance for which authorization is not required. Supplement 1 makes clear that the cost of used fixtures or used mechanical equipment need not be included in estimating the cost of a job.

"Fixtures" are defined as any article attached to a building or structure and used as a part of the building or structure. "Mechanical equipment" is considered to be any equipment used to operate a building or other structure, that is, plumbing, heating, ventilating, and lighting equipment.

The following fixtures and mechanical equipment articles [among others] are covered by the order, both regarding the installation of the item itself and any alterations to a structure involved in the installation:

Air conditioning equipment (except when used for humidity or temperature control in industrial processing or as refrigeration equipment in a cold storage warehouse or a frozen food locker plant and except self-contained individual units with no duct systems).

Furnaces and furnace burner or boiler burner units.

Heating equipment.

Ventilating equipment.

Any other article falling within the definitions of fixture and mechanical equipment stated above.

Installing replacement parts in existing mechanical equipment was exempted from the coverage of VHP-1. The supplement specified that this exemption applies to the replacement of parts which are not serviceable, but does not exempt the replacement of an entire piece of equipment. For example, authorization is not required to replace the grates in a furnace or the tubes in a boiler but is required to replace the entire furnace or boiler, unless the total cost of replacement comes within the small job allowance.

"All Possible Encouragement to Apartment Construction"

Thousands of Veterans Aren't in Position to Buy Homes, Housing Expediter Wyatt Says . . . . . Big Projects Will Provide Employment

Reports received from many large cities indicate an increasing interest in large scale rental projects as a part of the veterans emergency housing program, according to Wilson W. Wyatt, national housing expediter, in a statement last month.

"The need for rental housing can't be underestimated, so we intend to give all possible encouragement to the construction of apartment buildings, large and small," Mr. Wyatt said. "They not only will provide the type of housing many veterans need, but the large projects will furnish jobs to types of workers who are not generally employed on small home construction."

Mr. Wyatt pointed out that thousands of veterans in all sections of the country are not now in a position to buy homes of their own. "A large number are seeking jobs best fitting their capabilities and are not firmly established to the point where they are ready to settle down to a lifetime job in a specific community," he added. "Many of them are completing their educations or embarking on their first jobs and consequently do not wish to be tied down by an investment in a permanent home."

Mr. Wyatt said that plans for such rental housing had been announced at the very inception of the program.

"Of course, all multiple dwelling projects—like individual homes—must be within the rental limits prescribed under the veterans emergency housing program, which sets a top rent of $80 a unit," Mr. Wyatt said.

Predicts Billion Dollar Boost in Nonresidential Construction

Wyatt Says Government Program to Stimulate Nonhousing Volume Too

A BILLION dollar increase in nonresidential construction during 1946-47, even with the limitation order curtailing nonessential and deferrable projects, is scheduled under the veterans emergency housing program, according to Wilson W. Wyatt, national housing expediter.

Moreover, current estimates of the Bureau of Labor Statistics indicate that at the peak of the housing program in 1947 almost twice as many workers will be needed for nonresidential construction as are now employed in that type of building.

In other words, there will be *more*, not *less*, employment, building, and investment in the heavy construction nonresidential fields, Mr. Wyatt emphasized. Fears that the limitation order signifies a stoppage of heavy construction building are unfounded and based on a misunderstanding of the order and the building program, he said last month.

"The program calls for a greatly accelerated production of building materials," Mr. Wyatt explained. "While the bulk of this increased production will go into home building, some of it will go into essential nonresidential construction.

"So, actually, the program will stimulate a larger volume of nonhousing construction than we would have had without the program."

Schools, Hospitals, Factories

The effect of the limitation order, he explained, will be to screen out nonessential and deferrable commercial and industrial construction —such as night clubs, race tracks, motion picture theaters. On the other hand, materials and manpower will be made available to essential projects such as schools, hospitals, highways, streets, sewers and other utilities needed in support of the housing program as well as industrial plants producing needed materials or providing needed employment.

Mr. Wyatt cited Bureau of Labor Statistics employment figures both for on-site residential construction and for all other construction. In March, BLS reported, 360,000 workers were employed on-site in home building and 800,000 were employed on-site in all other new construction.

By next September, expected peak month for 1946,* the bureau estimated that 975,000 on-site workers will be required for the Wyatt home building program and 900,000 for all other new construction. And at the 1947 peak, 1,100,000 will be needed for the veterans emergency housing program and 1,500,000 for all other new construction.

$23 Billion for Nonresidential

Nonresidential construction, repairs and maintenance — *without* the program and limitation order— were estimated to reach $22 billion in 1946-47. Thus, the present goal of $23 billion represents a 4 per cent greater volume than there would be without the emergency program. And, at the same time, the emergency program and the limitation order will assure 65 per cent more home building than there would be without the program and the order, says the National Housing Agency.

A huge volume of heavy construction work which was under way before March 26, date of the limitation order, is not affected by the order. That work will continue, and is expected to provide a backlog of some months of employment for heavy construction workers. As the months go by, it is expected that building materials will become much more plentiful — and that as they become more plentiful, prohibitions against nonessential construction can be relaxed.

Of the 2,700,000 dwelling units* to be started before the end of 1947 under the veterans emergency housing program, a large number will be in the form of large apartment houses and multiple dwelling projects. These large-scale projects will also add to the demand for many types of heavy construction workers.

Order Doesn't Restrict Process Piping

In connection with the above estimate of nonresidential construction volume under the terms of the general restrictions on construction and repairs as given in the veterans housing program order No. 1, it is interesting to review the kinds of work that are exempt from the order's terms. In general, it should be stressed that the order applies only to buildings, and does not restrict installation of productive facilities in buildings—such as process piping.

Quoting from the order, its restrictions "apply to construction, repairing, making additions or alterations (including alterations incidental to installing any kind of equipment), improving or converting structures, or installing or relocating fixtures or mechanical equipment in structures. These terms include any kind of work on a structure which involves the putting up or putting together of processed materials, products, fixtures or mechanical equipment, if the processed materials, products, fixtures or mechanical equipment are attached to the land, or are attached to a structure and used as a functional part of the structure, or

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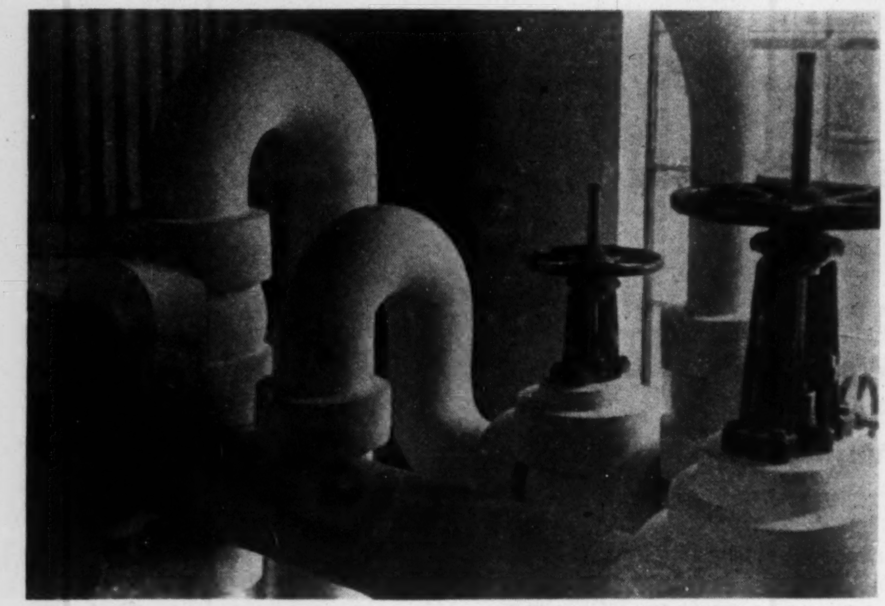
*These estimates may be affected by the coal strike—Ed.



Photos courtesy C. W. Johnson, Inc.

Process piping is not restricted

are attached so firmly to the land or structure that removal would injure the material, product, fixture or mechanical equipment or the structure. The laying of asphalt or other tile or linoleum cemented or otherwise attached to the structure is covered by the order. However, repainting, repapering, and sanding floors, and greasing, overhauling, repairing or installing repair or replacement parts in existing mechanical equipment in all types of structures, where no change in the structure is made, are not covered by the order.

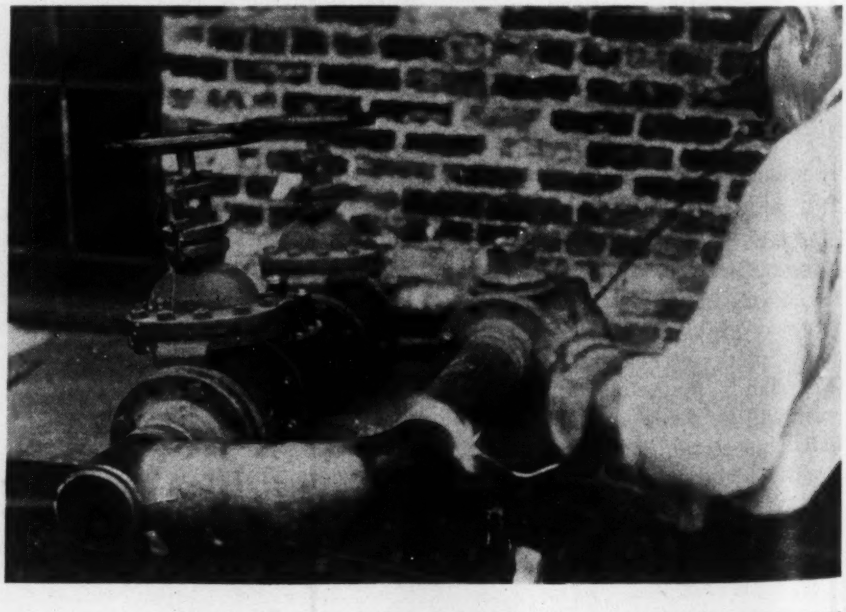
"The term 'fixture' means any article attached to a building or structure and used as a part of the building or structure. The term 'mechanical equipment' means any equipment which is used to operate a building or other structure. The following items are included within the phrase 'fixtures and mechanical equipment' if they are attached to the building or structure in any of the ways indicated later in this paragraph: plumbing, heating, ventilating and lighting equipment, panelling, bookcases, bars, soda fountains, show cases, booths, wood or metal partitions, counters, and the like. These articles are considered to be attached to a building or structure if they are attached by nails or screws to the building, if they are connected to the plumbing or other piping system of the building, if they are connected to the lighting system of the building (except by connection to an existing outlet), or if a base or foundation is built for the item, or if the item is cemented to the building or structure.

"The phrase 'fixtures and mechanical equipment' does not include the following: machine tools, blast furnaces, conveyors, elevators, process piping, control or testing equipment used for industrial or utility purposes or in a laboratory, power generating or transmitting equipment, such as boilers, generators, transformers, and the like (however, where the purpose of boilers, transformers and similar equipment is primarily to provide electricity or steam for lighting or heating the building in which they are installed, they would be mechanical equipment), medical equipment in a hospital, washing machines, or dryers in a commercial laundry, compressors or cooling equipment in a cold storage warehouse or frozen food locker plant, gasoline pumps and hydraulic lifts in a garage or service station, and stoves, refrigerators (other than refrigerators constructed as an integral part of a building), food warming equipment and dishwashing equipment in a restaurant."

Maintenance and Repair

The prohibitions of the order do not apply to maintenance and repair work in structures. "Maintenance" means the minimum upkeep necessary to keep a structure in sound working condition and "repair" means the restoration of a structure to sound working condition when the structure has been rendered unsafe or unfit for service by wear and tear, damage, failure of parts, or the like. However, neither maintenance nor repair includes the improvement of any structure by replacing material which is still usable with material of a better kind, quality or design. No maintenance or repair work which is capitalized by the person doing the maintenance or repair work may be performed under this exemption. Alterations to a building or other structure, including alterations incidental to installing of equipment, are not exempted by this paragraph, even though they are not capitalized, and may only be done and to the extent permitted under the order or when specifically authorized.

Maintenance and repair are exempt



Comparative ENGINEERING DATA on REFRIGERANTS Given in New TABLES

In deciding which refrigerant to use under a specific set of conditions, tables are needed which give engineering data such as weight and volume of refrigerant to be circulated per ton, and horsepower and capacity. Such tables, in addition to the basic data on thermodynamic properties, are of value in showing at a glance just which refrigerant would be desirable under a given set of circumstances.

For this reason various sets of tables* have been prepared for "Freon"-11, -12, -21, -22, and -113, ammonia, methyl chloride, and water vapor. These tables enable the user to make rapid comparisons of the important basic data needed in deciding whether a refrigerant is suitable for a given set of circumstances. Temperatures are shown in degrees Fahrenheit.

The tables are easy to use. The temperature of the liquid ahead of the expansion valve is equal to the condensing temperature if no subcooling takes place. However, a small amount of subcooling usually takes place in most condensers. It is reasonably safe to figure that the temperature of the liquid ahead of the expansion valve will be about 5 F lower than the actual condensing temperature. The actual condensing temperature corresponding to any given head pressure can, of course, be found in the tables for saturated liquid.

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*See HPAC, June 1944, pp. 337-338, July 1944, p. 409, August 1944, pp. 478-480, October 1944; pp. 593-594, May 1945, pp. 256-258, December 1945, pp. 616-618, and March 1946, pp. 91-93.

"Freon-113"—Theoretical capacity of refrigerating compressors
(Saturated vapor leaving evaporator)

Tons per cu ft per min of vapor compressed

Evap Temp	Temperature of liquid ahead of expansion valve													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	0.00475	0.00466	0.00457	0.00448	0.00439	0.00429	0.00420	0.00411	0.00401	0.00392	0.00382	0.00373	0.00363	0.00354
-18	.00510	.00500	.00491	.00481	.00471	.00461	.00451	.00442	.00431	.00421	.00411	.00401	.00390	.00380
-16	.00547	.00537	.00527	.00516	.00506	.00495	.00484	.00474	.00463	.00452	.00442	.00430	.00419	.00408
-14	.00586	.00575	.00564	.00553	.00542	.00531	.00519	.00508	.00497	.00485	.00473	.00462	.00450	.00439
-12	.00628	.00616	.00605	.00593	.00581	.00569	.00557	.00545	.00532	.00520	.00508	.00496	.00483	.00471
-10	0.00672	0.00660	0.00647	0.00635	0.00622	0.00609	0.00596	0.00583	0.00571	0.00557	0.00544	0.00531	0.00518	0.00505
- 8	.00719	.00706	.00692	.00679	.00665	.00652	.00638	.00625	.00610	.00597	.00583	.00569	.00554	.00541
- 6	.00768	.00754	.00740	.00726	.00711	.00697	.00682	.00668	.00653	.00638	.00623	.00609	.00593	.00578
- 4	.00821	.00806	.00791	.00776	.00760	.00745	.00729	.00714	.00699	.00683	.00667	.00651	.00635	.00619
- 2	.00876	.00861	.00844	.00828	.00812	.00796	.00779	.00763	.00746	.00729	.00713	.00696	.00678	.00662
0	0.00935	0.00918	0.00909	0.00884	0.00867	0.00849	0.00832	0.00814	0.00797	0.00779	0.00761	0.00743	0.00725	0.00707
2	.00996	.00978	.00961	.00943	.00924	.00906	.00887	.00869	.00850	.00831	.00812	.00793	.00774	.00755
4	.0106	.0104	.0102	.0100	.00984	.00965	.00946	.00926	.00907	.00887	.00867	.00846	.00826	.00806
6	.0113	.0111	.0109	.0107	.0105	.0103	.0101	.00987	.00966	.00945	.00923	.00903	.00881	.00859
8	.0120	.0118	.0116	.0114	.0112	.0109	.0107	.0105	.0103	.0101	.00983	.00961	.00938	.00916
10	0.0128	0.0126	0.0123	0.0121	0.0119	0.0116	0.0114	0.0112	0.0109	0.0107	0.0105	0.0102	0.00999	0.00975
12	.0136	.0134	.0131	.0129	.0126	.0124	.0121	.0119	.0116	.0114	.0111	.0109	.0106	.0104
14	.0144	.0142	.0139	.0137	.0134	.0132	.0129	.0126	.0124	.0121	.0118	.0116	.0113	.0110
16	.0153	.0151	.0148	.0145	.0143	.0140	.0137	.0134	.0132	.0129	.0126	.0123	.0120	.0117
18	.0163	.0160	.0157	.0154	.0151	.0148	.0145	.0143	.0140	.0137	.0134	.0131	.0128	.0125
20	0.0172	0.0169	0.0166	0.0163	0.0160	0.0157	0.0154	0.0151	0.0148	0.0145	0.0142	0.0139	0.0136	0.0132
22	.0183	.0180	.0176	.0173	.0170	.0167	.0164	.0160	.0157	.0154	.0150	.0147	.0144	.0140
24	.0193	.0190	.0187	.0183	.0180	.0177	.0173	.0170	.0166	.0163	.0160	.0156	.0152	.0149
26	.0205	.0201	.0198	.0194	.0191	.0187	.0184	.0180	.0176	.0173	.0169	.0165	.0162	.0158
28	.0217	.0213	.0209	.0206	.0202	.0198	.0194	.0191	.0187	.0183	.0179	.0175	.0171	.0167
30	0.0229	0.0225	0.0221	0.0218	0.0214	0.0210	0.0206	0.0202	0.0198	0.0194	0.0190	0.0185	0.0181	0.0177
32	.0242	.0238	.0234	.0230	.0226	.0222	.0218	.0214	.0209	.0205	.0201	.0196	.0192	.0188
34	.0256	.0252	.0247	.0243	.0239	.0234	.0230	.0226	.0221	.0217	.0212	.0208	.0203	.0198
36	.0270	.0266	.0261	.0257	.0252	.0248	.0243	.0238	.0234	.0229	.0224	.0219	.0215	.0210
38	.0285	.0280	.0276	.0271	.0266	.0261	.0256	.0252	.0247	.0242	.0237	.0232	.0227	.0222
40	0.0301	0.0296	0.0291	0.0286	0.0281	0.0276	0.0271	0.0266	0.0261	0.0255	0.0250	0.0245	0.0240	0.0234
42	.0317	.0312	.0307	.0302	.0296	.0291	.0286	.0280	.0275	.0269	.0264	.0258	.0253	.0247
44	.0334	.0329	.0323	.0318	.0312	.0307	.0301	.0296	.0290	.0284	.0278	.0273	.0267	.0261
46	.0352	.0346	.0341	.0335	.0329	.0323	.0317	.0311	.0306	.0300	.0293	.0287	.0281	.0275
48	.0371	.0365	.0359	.0353	.0346	.0340	.0334	.0328	.0322	.0316	.0309	.0303	.0296	.0290
50	0.0390	0.0384	0.0378	0.0371	0.0365	0.0358	0.0352	0.0346	0.0339	0.0332	0.0326	0.0319	0.0312	0.0306
52	.0410	.0404	.0397	.0391	.0384	.0377	.0370	.0364	.0357	.0350	.0343	.0336	.0329	.0322
54	.0432	.0425	.0418	.0411	.0404	.0397	.0390	.0383	.0376	.0368	.0361	.0354	.0346	.0339
56	.0454	.0440	.0439	.0432	.0425	.0417	.0410	.0402	.0395	.0387	.0380	.0372	.0364	.0357
58	.0477	.0469	.0462	.0454	.0446	.0439	.0431	.0423	.0415	.0407	.0399	.0391	.0383	.0375

"Freon-113"—Weight of refrigerant to be circulated

(Saturated vapor leaving evaporator)

Lb per min per ton of refrigerating capacity

Evap Temp	Temperature of liquid ahead of expansion valve													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	3.59	3.66	3.73	3.81	3.89	3.97	4.06	4.15	4.25	4.35	4.46	4.58	4.70	4.82
-18	3.57	3.64	3.71	3.79	3.87	3.95	4.04	4.13	4.22	4.33	4.43	4.54	4.67	4.79
-16	3.55	3.62	3.69	3.77	3.85	3.93	4.01	4.10	4.20	4.30	4.40	4.52	4.64	4.76
-14	3.54	3.60	3.68	3.75	3.83	3.91	3.99	4.08	4.17	4.27	4.38	4.49	4.61	4.73
-12	3.52	3.59	3.66	3.73	3.81	3.89	3.97	4.06	4.15	4.25	4.35	4.46	4.58	4.70
-10	3.50	3.57	3.64	3.71	3.78	3.86	3.95	4.03	4.12	4.22	4.32	4.43	4.55	4.66
- 8	3.48	3.55	3.62	3.69	3.76	3.84	3.92	4.01	4.10	4.20	4.30	4.40	4.52	4.64
- 6	3.47	3.53	3.60	3.67	3.74	3.82	3.90	3.99	4.08	4.17	4.27	4.38	4.49	4.60
- 4	3.45	3.51	3.58	3.65	3.72	3.80	3.88	3.97	4.05	4.15	4.25	4.35	4.46	4.58
- 2	3.43	3.50	3.56	3.63	3.71	3.78	3.86	3.94	4.03	4.12	4.22	4.32	4.43	4.54
0	3.42	3.48	3.54	3.61	3.69	3.76	3.84	3.92	4.01	4.10	4.20	4.30	4.40	4.52
2	3.40	3.46	3.53	3.60	3.67	3.74	3.82	3.90	3.98	4.08	4.17	4.27	4.38	4.49
4	3.38	3.44	3.51	3.58	3.65	3.72	3.80	3.88	3.96	4.05	4.15	4.24	4.35	4.46
6	3.37	3.43	3.49	3.56	3.63	3.70	3.78	3.86	3.94	4.03	4.12	4.22	4.32	4.43
8	3.35	3.41	3.48	3.54	3.61	3.68	3.76	3.84	3.92	4.01	4.10	4.19	4.30	4.40
10	3.34	3.39	3.46	3.52	3.59	3.66	3.74	3.82	3.90	3.98	4.07	4.17	4.27	4.37
12	3.32	3.38	3.44	3.50	3.57	3.64	3.72	3.79	3.87	3.96	4.05	4.14	4.24	4.35
14	3.30	3.36	3.42	3.49	3.56	3.62	3.70	3.77	3.85	3.94	4.03	4.12	4.22	4.32
16	3.29	3.35	3.41	3.47	3.54	3.61	3.68	3.75	3.83	3.92	4.00	4.10	4.19	4.29
18	3.27	3.33	3.39	3.45	3.52	3.59	3.66	3.73	3.81	3.90	3.98	4.07	4.17	4.27
20	3.26	3.32	3.37	3.44	3.50	3.57	3.64	3.71	3.79	3.87	3.96	4.05	4.14	4.24
22	3.24	3.30	3.36	3.42	3.48	3.55	3.62	3.69	3.77	3.85	3.94	4.02	4.12	4.22
24	3.23	3.28	3.34	3.40	3.47	3.53	3.60	3.67	3.75	3.83	3.91	4.00	4.09	4.19
26	3.21	3.27	3.33	3.38	3.45	3.51	3.58	3.65	3.73	3.81	3.89	3.98	4.07	4.16
28	3.20	3.25	3.31	3.37	3.43	3.50	3.56	3.64	3.71	3.79	3.87	3.96	4.05	4.14
30	3.18	3.24	3.29	3.35	3.42	3.48	3.55	3.62	3.69	3.77	3.85	3.93	4.02	4.12
32	3.17	3.22	3.28	3.34	3.40	3.46	3.53	3.60	3.67	3.75	3.83	3.91	4.00	4.09
34	3.15	3.21	3.26	3.32	3.38	3.44	3.51	3.58	3.65	3.73	3.80	3.89	3.98	4.07
36	3.14	3.19	3.25	3.30	3.36	3.43	3.49	3.56	3.63	3.71	3.78	3.87	3.95	4.04
38	3.12	3.18	3.23	3.29	3.35	3.41	3.48	3.54	3.61	3.69	3.76	3.84	3.93	4.02
40	3.11	3.16	3.22	3.27	3.33	3.39	3.46	3.52	3.59	3.67	3.74	3.82	3.91	4.00
42	3.10	3.15	3.20	3.26	3.32	3.38	3.44	3.51	3.58	3.65	3.72	3.80	3.89	3.97
44	3.08	3.13	3.19	3.24	3.30	3.36	3.42	3.49	3.56	3.63	3.70	3.78	3.86	3.95
46	3.07	3.12	3.17	3.23	3.28	3.34	3.40	3.47	3.54	3.61	3.68	3.76	3.84	3.93
48	3.06	3.10	3.16	3.21	3.27	3.33	3.39	3.45	3.52	3.59	3.66	3.74	3.82	3.90
50	3.04	3.09	3.14	3.20	3.25	3.31	3.37	3.44	3.50	3.57	3.64	3.72	3.80	3.88
52	3.03	3.08	3.13	3.18	3.24	3.30	3.36	3.42	3.48	3.55	3.62	3.70	3.78	3.86
54	3.02	3.06	3.12	3.17	3.22	3.28	3.34	3.40	3.47	3.54	3.61	3.68	3.76	3.84
56	3.00	3.05	3.10	3.15	3.21	3.26	3.32	3.38	3.45	3.52	3.59	3.66	3.74	3.82
58	2.99	3.04	3.09	3.14	3.19	3.25	3.31	3.37	3.43	3.50	3.57	3.64	3.72	3.80

"Freon-113"—Theoretical horsepower per cu ft per min of vapor compressed

Evap Temp	Condensing temperature													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	0.00472	0.00498	0.00525	0.00552	0.00573	0.00597	0.00621	0.00645	0.00669	0.00692	0.00714	0.00735	0.00759	0.00778
-18	.00488	.00517	.00546	.00571	.00597	.00623	.00649	.00674	.00699	.00724	.00748	.00770	.00795	.00816
-16	.00508	.00536	.00567	.00594	.00622	.00649	.00677	.00704	.00731	.00757	.00783	.00806	.00833	.00856
-14	.00525	.00556	.00589	.00618	.00647	.00676	.00705	.00734	.00763	.00791	.00818	.00844	.00872	.00896
-12	.00545	.00578	.00613	.00643	.00675	.00706	.00737	.00768	.00799	.00828	.00857	.00884	.00915	.00940
-10	0.00561	0.00597	0.00633	0.00666	0.00700	0.00733	0.00766	0.00799	0.00831	0.00863	0.00894	0.00923	0.00955	0.00982
- 8	.00577	.00615	.00654	.00689	.00725	.00759	.00795	.00830	.00865	.00898	.00931	.00962	.00996	.0102
- 6	.00593	.00633	.00675	.00712	.00750	.00787	.00825	.00862	.00899	.00934	.00969	.0100	.0104	.0107
- 4	.00611	.00654	.00698	.00738	.00778	.00817	.00858	.00897	.00936	.00974	.0101	.0105	.0108	.0112
- 2	.00626	.00672	.00718	.00760	.00803	.00845	.00887	.00928	.00971	.0101	.0105	.0109	.0113	.0116
0	0.00642	0.00691	0.00741	0.00785	0.00831	0.00875	0.00920	0.00964	0.0101	0.0105	0.0109	0.0113	0.0118	0.0121
2	.00654	.00706	.00759	.00805	.00854	.00900	.00948	.00995	.0104	.0109	.0113	.0117	.0122	.0126
4	.00669	.00724	.00781	.00830	.00881	.00931	.00982	.0103	.0108	.0113	.0118	.0122	.0127	.0131
6	.00678	.00737	.00796	.00849	.00903	.00955	.0101	.0106	.0111	.0116	.0121	.0126	.0131	.0136
8	.00692	.00754	.00817	.00872	.00930	.00985	.0104	.0110	.0115	.0121	.0126	.0131	.0136	.0141
10	0.00703	0.00768	0.00835	0.00894	0.00955	0.0101	0.0107	0.0113	0.0119	0.0125	0.0130	0.0136	0.0141	0.0146
12	.00708	.00776	.00847	.00909	.00973	.0104	.0110	.0116	.0122	.0128	.0134	.0140	.0146	.0151
14	.00717	.00789	.00863	.00929	.00997	.0106	.0113	.0120	.0126	.0133	.0139	.0145	.0151	.0157
16	.00723	.00799	.00878	.00948	.0102	.0109	.0116	.0123	.0130	.0137	.0143	.0149	.0156	.0162
18	.00728	.00809	.00892	.00966	.0104	.0111	.0119	.0126	.0134	.0141	.0148	.0154	.0162	.0168
20	0.00730	0.00813	0.00902	0.00979	0.0106	0.0114	0.0122	0.0129	0.0137	0.0145	0.0152	0.0159	0.0167	0.0173
22	.00722	.00810	.00904	.00983	.0107	.0115	.0124	.0131	.0140	.0148	.0156	.0163	.0171	.0178
24	.00719	.00812	.00910	.00994	.0108	.0117	.0126	.0134	.0143	.0152	.0160	.0167	.0176	.0183
26	.00720	.00818	.00922	.0101	.0111	.0120	.0129	.0138	.0147	.0156	.0164	.0173	.0182	.0189
28	.00711	.00814	.00924	.0102	.0112	.0121	.0131	.0140	.0150	.0160	.0168	.0177	.0187	.0194
30	0.00698	0.00807	0.00922	0.0102	0.0113	0.0122	0.0133	0.0143	0.0153	0.0163	0.0172	0.0181	0.0191	0.0200
32	.00682	.00797	.00918	.0102	.0113	.0124	.0135	.0145	.0156	.0166	.0176	.0186	.0196	.0205
34	.00662	.00782	.00910	.0102	.0114	.0124	.0136	.0147	.0159	.0169	.0180	.0190	.0201	.0210
36	.00638	.00764	.00898	.0102	.0114	.0125	.0137	.0149	.0161	.0172	.0183	.0194	.0205	.0215
38	.00610	.00742	.00883	.0100	.0113	.0125	.0138	.0150	.0163	.0175	.0186	.0197	.0210	.0220
40	0.00587	0.00726	0.00874	0.0100	0.0114	0.0126	0.0140	0.0152	0.0166	0.0178	0.0190	0.0202	0.0215	0.0226
42	.00549	.00695	.00850	.00985	.0113	.0126	.0140	.0153	.0167	.0180	.0193	.0205	.0219	.0230
44	.00503	.00656	.00819	.00960	.0111	.0125	.0140	.0153	.0168	.0182	.0196	.0208	.0222	.0234
46	.00467	.00630	.00801	.00946	.0110	.0125	.0141	.0155	.0171	.0185	.0199	.0212	.0227	.0240
48	.00412	.00583	.00762	.00914	.0108	.0123	.0140	.0155	.0171	.0186	.0201	.0215	.0230	.0243
50	0.00367	0.00543	0.00731	0.00893	0.0107	0.0122	0.0140	0.0155	0.0173	0.0189	0.0204	0.0219	0.0235	0.0248
52	.00314	.00498	.00695	.00865	.0105	.0121	.0140	.0156	.0174	.0191	.0207	.0222	.0239	.0253
54	.00240	.00433	.00639	.00817	.0101	.0118	.0137	.0154	.0173	.0191	.0208	.0224	.0242	.0257
56	.00174	.00376	.00594	.00777	.00977	.0116	.0136	.0154	.0174	.0192	.0210	.0226	.0245	.0261
58	.000807	.00292	.00521	.00712	.00921	.0111	.0132	.0151	.0172	.0191	.0209	.0227	.0247	.0263

"Freon-113"—Volume of refrigerant to be compressed

(Saturated vapor leaving evaporator)

Cu ft per min per ton of refrigerating capacity

Evap Temp	Temperature of liquid ahead of expansion valve													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	210	214	219	223	228	233	238	243	249	255	262	268	275	283
-18	196	200	204	208	212	217	222	226	232	237	243	249	256	263
-16	183	186	190	194	198	202	206	211	216	221	226	232	238	245
-14	171	174	177	181	184	188	192	197	201	206	211	216	222	228
-12	159	162	165	169	172	176	180	184	188	192	197	202	207	212
-10	149	152	154	158	161	164	168	171	175	179	184	188	193	198
- 8	139	142	144	147	150	153	157	160	164	168	172	176	180	185
- 6	130	133	135	138	141	144	147	150	153	157	160	164	168	173
- 4	122	124	126	129	132	134	137	140	143	146	150	154	158	162
- 2	114	116	118	121	123	126	128	131	134	137	140	144	147	151
0	107	109	110	113	115	118	120	123	126	128	131	134	138	141
2	100	102	104	106	108	110	113	115	118	120	123	126	129	132
4	94.2	95.9	97.7	99.6	102	104	106	108	110	113	115	118	121	124
6	88.4	90.0	91.7	93.5	95.3	97.2	99.2	101	104	106	108	111	114	116
8	83.1	84.6	86.2	87.8	89.6	91.4	93.2	95.2	97.2	99.4	102	104	107	109
10	78.2	79.6	81.1	82.6	84.2	85.9	87.6	89.5	91.4	93.4	95.5	97.7	100	103
12	73.6	74.9	76.3	77.7	79.2	80.8	82.4	84.1	85.9	87.8	89.8	91.8	94.1	96.4
14	69.3	70.5	71.8	73.1	74.6	76.0	77.6	79.1	80.8	82.6	84.4	86.4	88.5	90.6
16	65.2	66.4	67.6	68.8	70.2	71.5	73.0	74.5	76.0	77.7	79.4	81.2	83.2	85.2
18	61.5	62.6	63.7	64.9	66.1	67.4	68.8	70.1	71.6	73.2	74.8	76.5	78.3	80.2
20	58.0	59.0	60.1	61.2	62.4	63.6	64.8	66.1	67.5	69.0	70.5	72.1	73.8	75.6
22	54.8	55.7	56.7	57.8	58.8	60.0	61.2	62.4	63.7	65.0	66.5	68.0	69.6	71.2
24	51.7	52.6	53.5	54.5	55.5	56.6	57.7	58.9	60.1	61.4	62.7	64.1	65.6	67.1
26	48.8	49.7	50.6	51.4	52.4	53.4	54.5	55.5	56.7	57.9	59.1	60.5	61.9	63.3
28	46.1	46.9	47.8	48.6	49.5	50.5	51.4	52.4	53.5	54.7	55.8	57.1	58.4	59.7
30	43.6	44.4	45.2	46.0	46.8	47.7	48.6	49.6	50.6	51.6	52.8	53.9	55.2	56.4
32	41.3	42.0	42.7	43.5	44.3	45.1	46.0	46.8	47.8	48.8	49.8	51.0	52.1	53.3
34	39.1	39.7	40.4	41.2	41.9	42.7	43.5	44.3	45.2	46.2	47.1	48.2	49.3	50.4
36	37.0	37.6	38.3	39.0	39.7	40.4	41.2	42.0	42.8	43.7	44.6	45.6	46.6	47.7
38	35.1	35.6	36.3	36.9	37.6	38.3	39.0	39.7	40.5	41.4	42.2	43.1	44.1	45.1
40	33.2	33.8	34.4	35.0	35.6	36.2	36.9	37.6	38.4	39.2	40.0	40.8	41.8	42.7
42	31.5	32.0	32.6	33.2	33.8	34.4	35.0	35.7	36.4	37.1	37.9	38.7	39.6	40.4
44	29.9	30.4	30.9	31.5	32.0	32.6	33.2	33.8	34.5	35.2	35.9	36.7	37.5	38.3
46	28.4	28.9	29.4	29.9	30.4	30.9	31.5	32.1	32.7	33.4	34.1	34.8	35.6	36.3
48	27.0	27.4	27.9	28.4	28.9	29.4	29.9	30.5	31.1	31.7	32.3	33.0	33.7	34.5
50	25.6	26.0	26.5	26.9	27.4	27.9	28.4	28.9	29.5	30.1	30.7	31.3	32.0	32.7
52	24.4	24.8	25.2	25.6	26.0	26.5	27.0	27.5	28.0	28.6	29.2	29.8	30.4	31.1
54	23.2	23.5	23.9	24.3	24.8	25.2	25.6	26.1	26.6	27.2	27.7	28.3	28.9	29.5
56	22.0	22.7	22.8	23.2	23.6	24.0	24.4	24.8	25.3	25.8	26.3	26.9	27.4	28.0
58	21.0	21.3	21.7	22.0	22.4	22.8	23.2	23.6	24.1	24.6	25.0	25.6	26.1	26.6

"Freon-113"—Theoretical horsepower of refrigerating compressors

(Saturated vapor entering compressor)

Horsepower per ton

Evap Temp	Condensing temperature													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	0.993	1.07	1.15	1.23	1.31	1.39	1.48	1.57	1.67	1.77	1.87	1.97	2.09	2.20
-18	.957	1.03	1.11	1.19	1.27	1.35	1.44	1.53	1.62	1.72	1.82	1.92	2.04	2.15
-16	.929	0.998	1.08	1.15	1.23	1.31	1.40	1.48	1.58	1.67	1.77	1.87	1.99	2.09
-14	.896	0.967	1.04	1.12	1.19	1.27	1.36	1.44	1.54	1.63	1.73	1.83	1.94	2.04
-12	.868	0.938	1.01	1.09	1.16	1.24	1.32	1.41	1.50	1.59	1.69	1.78	1.89	2.00
-10	0.834	0.904	0.979	1.05	1.13	1.20	1.28	1.37	1.46	1.55	1.64	1.74	1.84	1.95
- 8	.802	.872	.945	1.02	1.11	1.17	1.25	1.33	1.42	1.51	1.60	1.69	1.80	1.90
- 6	.772	.840	.912	0.981	1.05	1.13	1.21	1.29	1.38	1.46	1.55	1.65	1.75	1.85
- 4	.744	.812	.883	0.951	1.02	1.10	1.18	1.26	1.34	1.43	1.52	1.61	1.71	1.80
- 2	.714	.781	.851	0.918	0.989	1.06	1.14	1.22	1.30	1.39	1.47	1.56	1.66	1.76
0	0.687	0.753	0.822	0.888	0.959	1.03	1.11	1.18	1.27	1.35	1.44	1.52	1.62	1.71
2	.656	.721	.790	.855	.924	0.994	1.07	1.14	1.23	1.31	1.39	1.48	1.57	1.67
4	.631	.695	.763	.827	.895	0.964	1.04	1.11	1.19	1.27	1.36	1.44	1.54	1.63
6	.600	.664	.731	.794	.861	0.929	1.00	1.08	1.15	1.23	1.32	1.40	1.49	1.58
8	.575	.638	.704	.766	.833	0.900	0.972	1.04	1.12	1.20	1.28	1.36	1.45	1.54
10	0.550	0.611	0.677	0.738	0.804	0.870	0.941	1.01	1.09	1.17	1.24	1.33	1.42	1.50
12	.521	.581	.646	.706	.770	.836	.905	0.976	1.05	1.13	1.20	1.28	1.37	1.46
14	.496	.556	.620	.680	.743	.808	.876	0.946	1.02	1.09	1.17	1.25	1.34	1.42
16	.472	.531	.594	.653	.715	.779	.846	0.915	0.988	1.06	1.14	1.21	1.30	1.38
18	.448	.506	.568	.627	.688	.751	.818	0.886	0.957	1.03	1.10	1.18	1.26	1.34
20	0.423	0.480	0.542	0.599	0.661	0.721	0.789	0.854	0.926	0.997	1.07	1.15	1.23	1.31
22	.395	.451	.512	.568	.630	.688	.755	.819	.890	.961	1.03	1.11	1.19	1.26
24	.371	.427	.487	.542	.602	.660	.726	.790	.860	.930	1.00	1.07	1.15	1.23
26	.351	.406	.466	.520	.580	.638	.703	.765	.835	.903	0.973	1.04	1.12	1.20
28	.328	.382	.441	.495	.554	.611	.675	.736	.805	.872	0.941	1.01	1.09	1.16
30	0.305	0.358	0.416	0.470	0.528	0.584	0.647	0.708	0.775	0.841	0.909	0.978	1.06	1.13
32	.282	.334	.392	.445	.502	.558	.620	.679	.746	.811	.878	.946	1.02	1.09
34	.259	.311	.368	.420	.476	.531	.593	.652	.717	.781	.847	.914	0.989	1.06
36	.236	.288	.344	.395	.451	.505	.566	.624	.688	.752	.817	.882	0.956	1.02
38	.214	.264	.320	.371	.426	.479	.539	.596	.660	.723	.787	.851	0.924	0.990
40	0.195	0.245	0.300	0.350	0.406	0.458	0.517	0.573	0.636	0.699	0.762	0.825	0.897	0.963
42	.173	.223	.277	.326	.381	.433	.491	.547	.609	.670	.732	.795	.866	.930
44	.150	.200	.253	.302	.356	.407	.464	.519	.580	.641	.702	.764	.833	.897
46	.132	.182	.235	.282	.335	.385	.443	.498	.558	.618	.678	.739	.807	.870
48	.111	.160	.212	.259	.312	.361	.418	.472	.531	.590	.650	.709	.777	.839
50	0.0940	0.141	0.194	0.240	0.292	0.341	0.397	0.450	0.509	0.568	0.626	0.685	0.752	0.812
52	.0764	.123	.175	.221	.273	.321	.377	.429	.487	.545	.603	.661	.727	.787
54	.0555	.102	.153	.199	.249	.297	.352	.403	.461	.518	.575	.632	.698	.757
56	.0382	.0842	.135	.181	.230	.277	.332	.383	.440	.496	.552	.609	.673	.731
58	.0169	.0623	.113	.158	.206	.253	.306	.357	.413	.469	.523	.579	.643	.700

Water Conditioning Is More Engineering Than Chemistry

Excerpts from a paper given by Leo F. Collins, chemical engineer, at the session on feedwater treatment held at the Midwest Power Conference

FORMAL discussions on water conditioning for steam generating purposes most often are of the nature of chemical dissertations, sparingly embellished with engineering diction. In contrast, the actual processing of water for a given plant usually involves a lot of engineering and a modest amount of chemistry.

In the higher ranges of boiler pressures, water conditioning partakes more and more of the nature of experimentation. Engineers conversant with overall aspects of plant operation recognize this limitation and, generally, are tolerant when troubles occur. But, when troubles occur at pressures for which the technology of water conditioning is virtually complete, they are usually quite emphatic in contending that such failures are manifestations of voids in the science of water chemistry.

The writer has spent more than 20 years in the latter class of plants, diagnosing and correcting such troubles and in conducting research studies of a complementary nature. This experience has embraced a variety of industrial plants, and those serving large institutional building groups, as well as utility plants. In this capacity, he has observed that *recurrent troubles* are more often the result of misapplication of the art of treatment than of voids in the science of water chemistry.

Basic Causes of Recurrent Troubles

Unwarranted efforts to economize and inadequate instruction of those responsible for the actual operation of treating equipment have been observed as most frequently the basic causes for recurrent troubles.

It would seem to be axiomatic that if a water treating system is to yield satisfactory results, it must be designed to "fit" not only the technological (i.e., the chemical and physical) requirements of the plant, but also the talent available for its operation. Very often the latter consideration is overlooked, and the complexities so originated are exaggerated by overzealousness in holding first costs to a minimum. What is involved can be better appreciated by considering the expedients usually employed in minimizing such costs. They are:

1) Preliminary studies are omitted or superficially conducted.

2) Inadequate treating capacity is provided.

3) Too few operating guides are supplied.

4) Treating equipment is "stuffed" into the plant.

OVER 20 YEARS of experience in the field of water conditioning has demonstrated to the author that recurrent troubles are more often the results of misapplication of the art of treatment than of voids in the science of water chemistry; and that errors in the art of treatment usually stem from unwarranted attempts to economize on first costs, and to inadequate instruction of operators, or both. He stresses here the necessity for making preliminary studies, supplying adequate capacity and operating guides, and for housing treating equipment in places where intelligent operators will work. It is also stressed that operators should be instructed more in detail than is required merely to conduct routine tests, and that all plants can well afford to provide competent technical supervision. . . . Mr. Collins, chemical engineer, The Detroit Edison Co., is a member of HPAC's board of consulting and contributing editors.

A competent method of treatment is one which consistently produces satisfactory results and requires a minimum of operating attention. Those systems that can be made to produce acceptable results, but in doing so demand frequent adjustments, are almost certain to develop troubles. It is a characteristic of such systems that they have been predicated more upon assumptions than upon the results of adequate preliminary studies.

If any plant is to acquire an optimum method of treatment, preliminary studies are mandatory; These should be made by a technologist, responsible for the development of *the entire treating system*.

Treating Capacity

In plants where the entire treating method consists merely in introducing chemicals into the feedwater or directly into the boiler, so little treating equipment is involved that virtually no considerations of treating capacity are involved. However, it should probably be pointed out that in some plants the use of limited treatment requires that boilers be operated at lower steaming rates than is otherwise possible. Thus, indirectly at least, such treatments lack capacity.

Where more "elaborate" treating schemes are involved, one of two

WATER LOG – Weekly

Plant ______________________

______________ MONTH 19___ YEAR

BOILER WATER

		UNIT No. ___					UNIT No. ___					OPERATOR INITIALS
	DAY	NaCl	NaOH	Na_2SO_3	PO_4	$NaNO_3$	NaCl	NaOH	Na_2SO_3	PO_4	$NaNO_3$	
MORNING SHIFT												

FEEDWATER CYCLE

		RAW	SOFTENED		OUTLET FEEDWATER HEATER					STEAM		OPERATOR INITIALS
	DAY	Alk	Alk	Hardness	PH Value	NaCl	Oxygen	Temp °F	Pressure psi	CO_2	Oxygen	
AFTERNOON SHIFT												

SECONDARY CHEMICAL FEED

		Inches of Solution Fed	CHEMICALS TO TANK*				DAILY CAPACITIES—M-lbs		OPERATOR INITIALS
	DAY		PO_4 lbs	Sulfite lbs	Nitrate lbs	Water Inches	Steam	Blowoff	
NIGHT SHIFT									

* Tank (Capacity—gallons per inch of height) should be recharged at midnight.

IMPORTANT— Write on the back of this log any features of operation you feel have influenced water conditions.

policies is usually pursued: Occasionally, it is held that if one treating unit becomes inoperative, there should still remain adequate capacity to meet the maximum boiler demand. More often it is held that the treating system should be capable of operating under overload conditions to meet peak demands.

The former is generally regarded as ultraconservative engineering and the latter as the more reasonable approach. A more critical analysis, however, does not always agree with the commonly accepted view.

It is well known that steam can be produced from inadequately conditioned water—even a scale former. To avoid serious damage, boilers are usually operated at low steaming rates and are cleaned internally at rather frequent intervals.

It is equally as well known that when the feedwater is precisely conditioned, the steam generating capacity of a given boiler is limited principally by the capacity of the fuel burning equipment.

To meet a given plant demand, therefore, one of two expedients may be employed: Either adequate "essential" equipment may be provided which, when operated at low steaming rates, will meet the plant demand, or a minimum of "essential" equipment, plus refinements which facilitate high steaming rates, may be utilized.

Operating Guides

Since the modern industrial steam boiler is one of the world's most critical users of water, chemical conditions must be maintained within rather narrow limits almost constantly or troubles are inevitable. Accordingly, all the processes used in conditioning the feedwater must be closely controlled. To this end, means for detecting changes *as they occur* are the acknowledged wants.

At present, meters that will measure chemical concentrations and that are otherwise suitable for installation in power plants are unavailable. Pending their development, the following substitutes must be used.

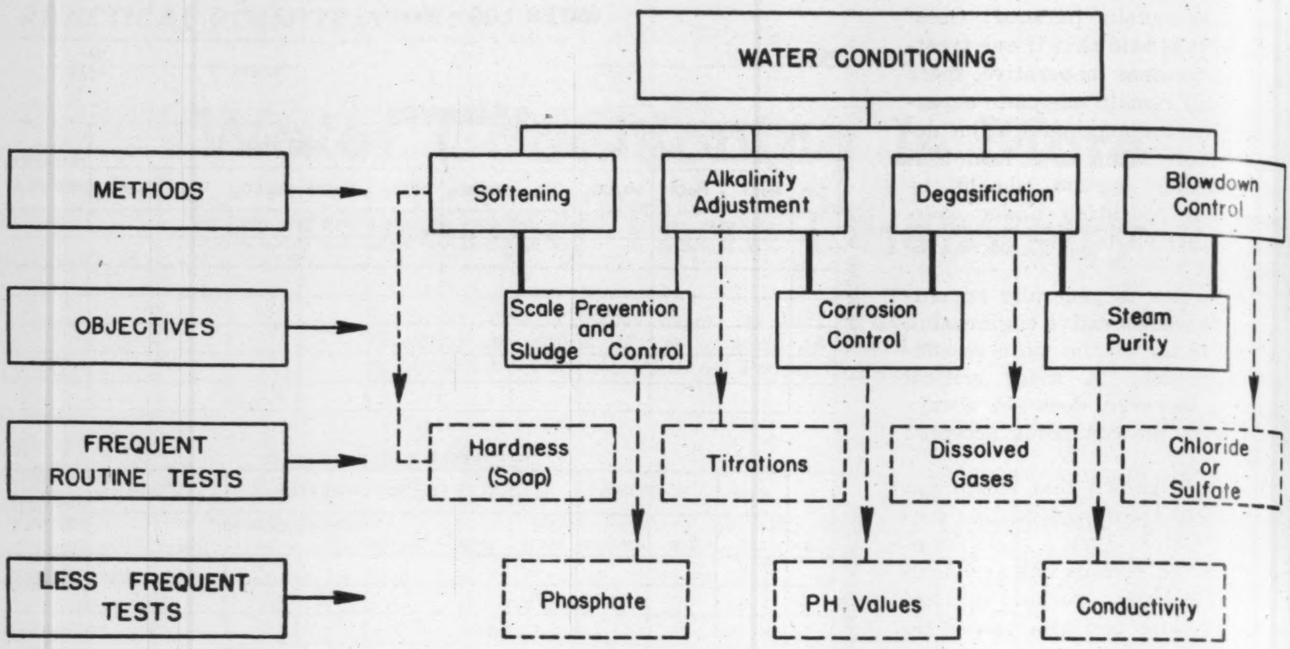
1) Indicating and recording instruments that reveal physical changes.

2) Sampling and routine chemical testing apparatus.

3) A *system* for keeping records.

In the first named class are thermometers, pressure gages, and other comparable instruments designed to measure physical conditions. Insofar as water conditioning is concerned, the measurements of physical conditions are of value only when their relation to chemical conditions is known. For example, if the thermometer in the water space of a deaerating heater reveals a temperature substantially lower than the temperature of saturated steam at the pressure indicated by the gage on the steam space of the same heater, it is indicated that the unit is "gas bound" and, therefore, that intolerable amounts of oxygen are inevitable in the effluent.

Conceivably, neither the pressure gage or the thermometer are essential insofar as the mechanics of operation are concerned. But, the example should suffice to show that the mechanics of operation are *not* necessarily the criteria that determine the instruments required for water processing. Thus, instruments of this type are sometimes required which, from a mechanical standpoint, appear superfluous. They should be located at key points and a routine established whereby operators are required to *read and record* the results thus made available. Unless such a routine is established, it is almost a certainty that such instruments will eventually be overlooked.



SUGGESTED TRAINING CHART

Sampling Facilities

There is no gainsaying the fact that routine chemical tests are a poor substitute for continuous records. But since they are the only known means for gaging certain essential chemical concentrations, nothing is to be gained by griping about them or in arbitrarily eliminating them. A more logical approach is to provide conditions that will expedite their performance. To this end, the following are helpful:

1) Sampling facilities that are approved and that preclude messing of the premises.

2) Chemical tests that are as simple as conditions will permit.

3) A clean, well lighted cabinet in which the tests may be performed and in which the test apparatus may be housed.

4) Forms upon which the results must be recorded and to which operators may readily refer.

Samples piped (usually with copper tubing) to a central point provided with a slop sink is the acknowledged want for routine control tests, but rarely are such facilities provided. Without them it is inevitable that the premises will be messed, and that the complaints that ensue will eventuate in samples being collected in a questionable manner. Poor samples and—as a result—faulty analytical results, are always misleading.

For most of the routine tests made on boiler waters, analytical techniques have been developed that are childishly simple. However, they are all predicated upon the proposition that the analytical tools will be kept clean, and the test will be conducted in well lighted spaces.

In the author's opinion, a double door stationary cabinet (mounted on legs about 18 in. high), the internal surfaces of which are sprayed with flat white paint and lighted by a daylight bulb or similar means, provides a suitable cabinet.

Forms for recording test results and other relevant data must usually be developed to meet individual plant requirements.

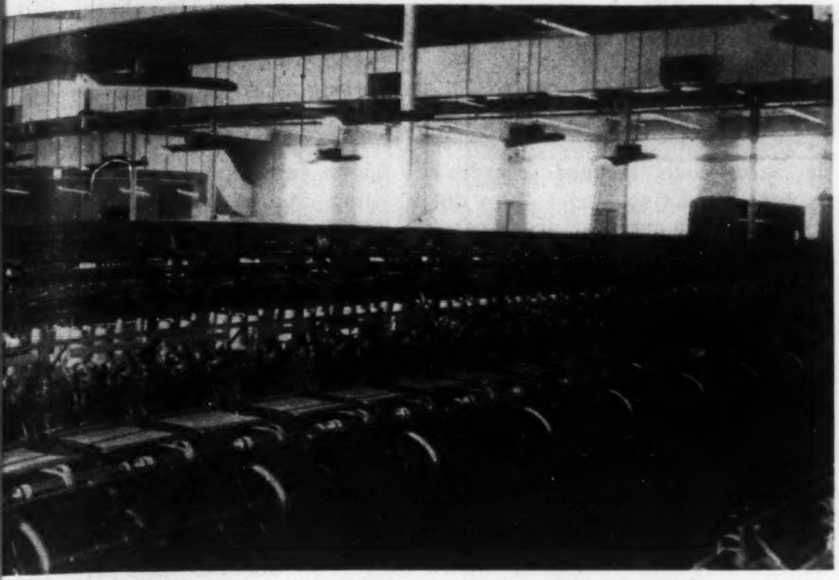
Technical Counsel

Technical counsel should have as its purposes not only the initial instruction of operators, but also to keep them instructed. Unless such coaching is provided, even good operators are likely to invent shortcuts that are unwarranted, to develop erroneous theories, and to forget. A good operator who conscientiously questions the validity of a given operation is entitled to a reasonable explanation.

Instructions along these lines need not and should not be in the form of academic lectures on chemistry. Nor should they be offered in large doses; spoon feeding is far more effective.

Even in an "elaborate" processing system, seldom are more than four major operations involved—softening, alkalinity adjustment, degasification, and blowdown control. The major and minor purposes of each can be demonstrated by means of a flow chart. If, subsequently, the control tests are attached, a working picture of the water processing system is obtained.

The ritual to be followed in the operation of various pieces of equipment and their limitations may best be detailed in the form of an operating manual, a copy of which should always be available. Therein may also be included an elementary discussion of the chemistry involved and an outline of the chemical test procedures to be followed.



This mill has recently extended its controlled conditions—including evaporative cooling—equipment for increased plant production. The conditioning apparatus is in unitary form suspended from the ceiling

Air Conditioning Requirements for Workers in Factories

THE EDITOR—I suppose that Mr. Mosher and I could carry on the pleasant discussion of air conditioning requirements for workers through all of your summer issues and far into the fall without exhausting this very interesting subject [see "Open for Discussion" in April HPAC and preceding issues].

I still contend, however, that Mr. Mosher's contentions and analyses were based on the assumption that a psychological response is a good basis of determination for a design condition of industrial air conditioning requirements rather than a physiological one.

Responsible for 40 Factories

Not very long ago I attended a meeting at which the representative of one of our largest corporations, having charge of some 40 odd factories for this corporation, was discussing the advisability of installing refrigeration air conditioning in some of their factories and he categorically stated that the most complaints they had had in the past summer were from the two or three factories in which refrigeration had been installed with the air conditioning. Personally, I do not believe that his investigation was thorough nor were the results he stated profound. I'm simply making this statement—that taking various persons' statements on comfort or on "ideal comfort" or "satisfaction" is a dangerous basis on which to predict the requirements of an entire industry.

There is no question that draftsmen working over papers, or people sitting at desks having very little to do except to think about their comfort, are not comfortable in fairly high temperatures with fairly high relative humidities. My experience has indicated that 85 F dry bulb with 52 per cent relative humidity, which corresponds to a 78 F effective temperature, would, however, satisfy the vast majority of workers as long as outside *dry* bulb temperatures were higher than the inside *dry* bulb temperatures.

"OPEN for DISCUSSION"

This condition, however, is not easily obtained with evaporative cooling. This condition represents a dew point of 66 F and consequently whenever the outside wet bulb is above 66 F this condition could not be obtained with evaporative cooling. The probabilities are that at least 20 days in the summer the wet bulb, in the communities that I have in mind, might rise to 75 F for a sufficient length of time to be distinctly noticeable and as only sufficient air would be introduced to maintain a condition of about 88 F with a 60 per cent relative humidity, or an effective temperature of about 83 F, comfort would be questionable. Without evaporative cooling, however, and the same quantity of air, one might have 107 F inside the factory with a 30 per cent relative humidity or an effective temperature of 92 F.

In the one case—that is, with evaporative cooling—working conditions would be at least safe, whereas without evaporative cooling the conditions would be beyond the limits which have been considered endurable except in the case of men in military service who were subjected to severe environmental conditions to which they seemed to react relatively easily.

Air Conditioning Most Desirable

My only object in continuing this discussion is to further the general use of air conditioning as the most desirable adjunct to industry comfort, health, and efficiency. On the one hand I'm anxious not to give industry the excuse of not putting in air conditioning because they can't afford refrigeration, and secondly, not to give labor the idea that they must, for their health's sake, have refrigeration in order to safely endure the burdens of their newly acquired curtailed day.

It would be an interesting analysis which Mr. Mosher might care to develop to work out what percentage increase in production would be necessary to pay for the increased cost of refrigeration air conditioning and its operation.—WALTER L. FLEISHER, consulting and advisory engineer; member of HPAC's board of consulting and contributing editors.

clerical burden in changing the data in the binder (where the binder happens to be looseleaf) or inserting typed or pasted corrections in permanently bound volumes.

I have found such large volumes to be cumbersome for ready handling and almost never refer to them, giving preference to the individual file pamphlets which are kept up to date and which give the latest improvements in products. As a substitute for these volumes I would recommend that the engineer or architect be provided with a standard filing cabinet and a mailing service, consisting of the manufacturer's descriptive literature and index card. This would promote a large saving in time, space, and paper and provide a high degree of flexibility.—T. H. URDAHL, Captain, USNR.

Simplified Procedure for Writing Specifications

THE EDITOR—In commenting on the article on simplifying specification writing, by George W. Campbell, published in the April HPAC, I am pleased to advise as follows:

Today—more than at any other time—great emphasis must be placed on efficiency, with a view to greater productiveness. Too much consideration cannot be given to utilizing the engineer's time in a manner to make the best full use of his professional talents. This calls for the elimination of all duties which can be performed by less skilled persons, or which fall into a clerical instead of a professional category.

In specification writing it is essential that a high degree of accuracy be maintained. Clarity and brevity are also desirable and toward this end the system described by Mr. Campbell will produce the desired result with a minimum of professional time. It should also be noted that a specification written in the manner discussed in his article eliminates the monotonous wordiness that characterizes many specifications.

It also insures that specifications are continually improved, which is not the case where previous specifications are used for a model and recopied over and over again. Some specification writers will clip portions of old specifications and paste these together in proper order in preparing a new specification. This method does not guarantee a continual overhauling of specification clauses and material.

Issue Standard Specification Cards

Mr. Campbell points out that this system could be expanded through the cooperation of manufacturers, whereby they would issue to architects and engineers a standard specification form card which they would mail, together with their descriptive literature. This would be a very beneficial time saver and serve a dual purpose, (a) as a specification and (b) as an index to the manufacturer's product, since the cards could be filed according to the respective items they describe and the manufacturer's catalog be filed alphabetically.

High Degree of Flexibility

It would also be desirable to have all manufacturers' data of one standard size in leaflet form rather than in a bound catalog. For example, a company's line might include 10 products concerning which the descriptive literature would be bound in one volume. Such a volume cannot be readily filed by subject, is cumbersome for the designer to handle, and adds an additional

Construction . . . Industry or Racket?

THE EDITOR—I have read with interest the article of the above title by Lester T. Avery, published in the April Heating, Piping & Air Conditioning, defending contractors in the building industry against charges of being responsible for high building costs. It is a timely article. I do not believe that any charge that contractors are responsible for the situation that exists in the building construction industry today is generally accepted, but there can be no denying that something has gone out of joint in the industry. The federal housing agencies have been talking of a $6000 home for returning GI's, with a $10,000 home permitted under certain conditions. These prices must include the cost of land and building. A study shows that in Chicago the kind of a building that can be erected to be sold within these ceiling limitations would provide what to most Americans would now be considered substandard living.

Three Times the 1943 Cost

In 1943, while war production was at its highest pitch, we had occasion to erect a small building which at that time cost $38,000. Within the last three months we solicited proposals for a similar building and the lowest proposal received was approximately three times the cost in 1943. Material costs have not increased 200 per cent nor have building trade wage scales; just how much the output per man has decreased is difficult to measure.

I am close to the housing problems of one returned GI whose case is typical. Before he went into the service late in 1943 he was interested in buying a typical American home of six rooms and one and one-half baths. Such a home he could have had for $11,000 in a good neighborhood. When he came out of the service early in 1946 he found the same home was being offered at $18,000 and now is being quoted at $20,000. A quick survey of builders soon convinced him he could do no better in dealing with a building contractor on the basis of construction of a new similar house.

While he was in the service those who stayed at home raised prices

"What I like about your magazine is that you like 'discussion' and you seem not to be afraid of it."—From a letter to the editor.

on him so he did not come back to the same country he left. The whole fantastic increase in building costs that has taken place within the last two years seems to be a combination of high labor costs, high costs of material, increased taxes on the contractors making it necessary for them to have increased margins, and increased costs of architectural and engineering services. It is a sellers' market for those who can deliver so high prices have not checked the demand as yet.

Pressure Groups and Restrictive Code Clauses

To ignore the fact that there are pressure groups both in labor and in material suppliers striving to maintain certain restrictive clauses in building codes in many cities is merely aping the ostrich that sticks its head in the sand so it cannot see danger. There are such groups and there are modifications that might be made in building codes to speed up building construction and reduce building costs without jeopardizing health and safety.

Material and labor will be short for some time. Stockpiles of lumber and other materials in yards were used up during the war emergency; they have to be replaced from their place of origin. The younger men were all in the service so there has of necessity been a gap of five years in training programs for young men in the building trades. It will take more than a year to bring about an adequate supply of material for building and more than two years to eliminate the shortage of skilled mechanics. Until that time the building costs will be high and everyone in the building profession will be subjected to criticism by a public that can think of no reason for the high costs except the general charge of profiteering.—John Howatt, business manager and chief engineer, Chicago Board of Education; member of HPAC's board of consulting and contributing editors.

WHEN ENGINEERS gather to hear a paper or talk, there comes a time when the meeting is thrown "open for discussion." We follow this custom in these columns, which provide an opportunity for readers to comment on articles published in HPAC; discuss other topics of interest to heating, piping, and air conditioning engineers and contractors; ask questions, etc.

INDUSTRY ASKED TO HELP GET TECHNICAL DATA

The Office of the Publication Board and the War Department are about to begin a complex and difficult operation, the selection and microfilming in Germany of technical data that may be valuable to American science and industry. Since it is impossible for any government agency to determine what items in the enormous mass of material may be valuable, a plea for help has been issued.

Industries and scientific groups are requested to suggest specific information that should be sought. Any suggestions as to where valuable documents may be found and as to those German industries possessing information not now available will be appreciated. Qualified technicians in a number of industrial fields are needed to carry on the work of searching German files. A knowledge of technical German is essential and appointments are subject to civil service approval and are made for a minimum of six months.

For any industry or scientific group interested in specific German industrial methods and able to assign personnel to visit Germany, a special mission will be considered. All persons who can offer helpful and pertinent suggestions are asked to write to the Department of Commerce, Office of the Publication Board, Washington 25, D. C.

W. P. DAVIS APPOINTED MANAGING DIRECTOR OF ICI

Walter P. Davis has been appointed managing director of the Indoor Climate Institute, with headquarters in Detroit. During the past nine years he has been supervisor of the promotional activities with the Buffalo Niagara Electric Corp., executive secretary of the Oil Heat Association of Western New York, secretary of the Buffalo Stoker Association, assistant secretary of the Electric Association of the Niagara Frontier, and executive secretary of the Indoor Climate Council of Western New York.

BUFFALO ESTABLISHES ENGINEERING SCHOOL

Establishment of a school of engineering at the University of Buffalo and the appointment of Prof. Paul E. Mohn as its dean was announced last month by Chancellor Samuel P. Capen, who asserted that the need for training in engineering in the community has grown so great and the enrollment in engineering courses has increased so markedly, that the council of the university decided to advance the department of mechanical engineering to a full division. Prof. Mohn has headed the department since its establishment in September 1944.

The new school will be housed in the engineering building now under construction. The building is expected to be completed by October. A campaign for funds for the construction and equipment of the building is in progress.

Dean Mohn's industrial contributions include the design of a line of warm air furnaces, development of wet bulb thermocouples for laboratory use, and development work and tests on fans for barrage balloons.

COLLIER ELECTED CRANE CHAIRMAN

John H. Collier was elected chairman of the board of directors of Crane Co. last month to fill the vacancy left by the death of J. B. Berryman in August 1945. J. L. Holloway, formerly vice president in charge of the finance and control division, succeeds Mr. Collier as president, and the responsibilities of P. R. Mork, executive vice president, were expanded.

TIMELY TOPIC

Let's Get Down to Cases on BUILDING COSTS!

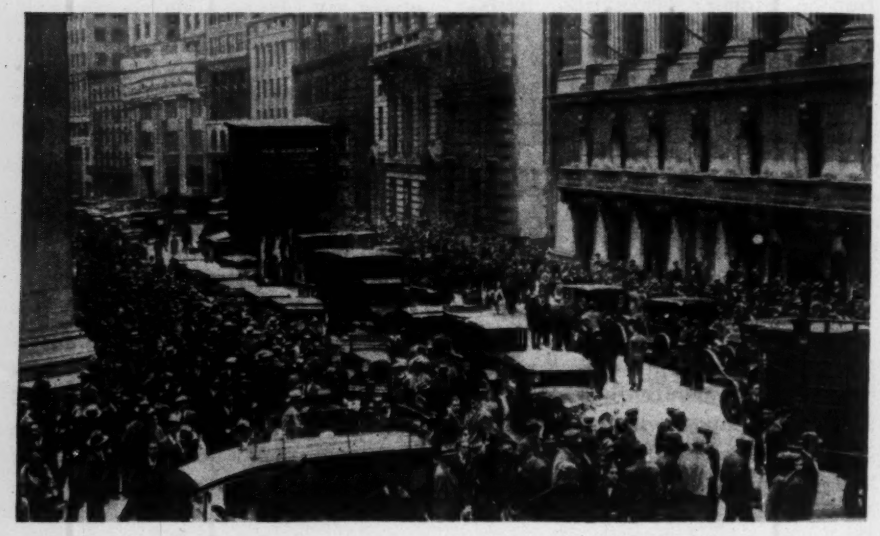
By Lester T. Avery
President
Avery Engineering Co.

IT HAS been my observation that increased *quantity* of building does not follow reduction in *cost*. Go back to 1919, just after the last war. The building trades were getting strong in the major cities and there was a lot of controversy between trades, between nonunion and union trades, and some interests tried to maintain open shop construction. It soon became obvious that the most expensive part of building was its *financing* and any delay in finishing due to any cause increased the cost. For example, a home that took six months to build cost more than one that took three months—and less than one that took a year. In large construction—such as apartments, hotels, or banks (of which there were many in the early 20's)—it meant that the important thing *to the owner* was to get the job done, and done quickly. So, due to the pressure from the *financing* interests, who could make money on a finished building, but lost money on an argument that delayed construction, the larger contractors were persuaded to recognize unions, deal with them fairly, and keep the jobs going.

This thinking prevailed and gradually all construction became unionized under the AFL building trades. For a time, Toledo contractors, for example, held out and ran an open shop town, and Detroit pretended to be nonunion in certain trades. Columbus, Ohio, had a mixture of union and nonunion construction. Actually, however, the cost of construction was about the same in the open shop areas as in the unionized, because the union rates were used as a yardstick in the nonunion construction.

This made a reasonably stable real estate valuation and financing structure — which appeared sound up to about 1928, a year before the famed stock market crash. Building costs were high, and the last big swing was in theater building and the construction of some monumental piles — like the Terminal group in Cleveland. Housing dropped off, apparently because there was enough.

"Smarter men than I have tried to explain the 1929 market crash"



Smarter men than I have tried to explain the stock market crash and this article is concerned only with the building business. You all remember (or should) how building volume gradually dropped off during 1929, 1930, 1931, and finally hit a low in 1932. Material costs were gradually coming down, union wage scales were being reduced—steamfitters from $1.62½ in 1929 to $1.25 in 1932 — contractors were skinning margins and swapping dollars and going broke—but building *did not pick up*.

In 1931 building costs were admittedly 20 per cent lower than they had been in 1929 and Hoover urged everyone to build. I did build a home in that year. My house was finished, but I paid off directly the last payments to the plumber, painter, and screen manufacturer by permission of the general contractor—but he went broke on the next house and was unable to finish it. The worst of the matter was that our financial institutions were being hurt by this distress in real estate values. They didn't know where the bottom was. Would wages in the trades go on down to 50c an hour, as they were in 1903 when my dad built his house? If you wanted to build and tried to borrow the money you were given a 50 per cent loan on an appraisal 80 per cent of cost. Then the banks began to close.

At that time, 1932, the building industry was on the rocks. Wage scales meant nothing, as it was common knowledge that men were working for less than scale by paying back to the contractor a part of the collected wage. Contractors were "second guessing" on every

EVERYONE FEELS free to criticize the construction industry these days, and from some of the stuff you read and hear you'd think it was nothing but a racket. Part of this criticism may be justified, but too much of it is far from reasonable and far from helpful. . . . . . In this and a preceding article, Mr. Avery—who has been very close to the construction industry for many years—points out a few of the things the curbstone critics usually fail to mention. Among his suggestions are the organization of several trades into one general trade; he also has something to say about the evils of competitive bidding. . . . . . Certainly, with the great need for building of all kinds (including housing), his subject is a most timely one. We hope you'll find his remarks of interest, and that you'll express your views for publication in our "Open for Discussion" columns.

job, shopping of bids being commonly indulged in by all. Right then a lot of people got out of the building business and never came back, and right then the fellows who stayed in started thinking about controlling competition so it would be "honest" and not "suicidal." You probably could have busted the building trades unions at that time if you had wanted to. But you decided you did not want to. How did *you* have anything to say about it?

Your bank and *your* insurance company decided it for you. They saw that a continued liquidation of building values would destroy the so-called "good" banks and insurance companies as it had destroyed the weaker ones. They saw apparently reliable material manufacturers, distributors, and contractors of all kinds—the people who borrowed the money on ordinary commercial paper — being liquidated. They found themselves in the hotel business, the apartment business, the manufacturing business, and even in the contracting business. And they also found these were specialized businesses and the best people they could hire to run them were the people who had the know-how and were the same people who had gone broke because of a falling market—not because of bad judgment or dishonesty.

Building Trades Unions Necessary

Then the New Deal came in, started a make work construction program, forced the contractors to organize, control and exchange prices (remember the NRA?), wrote construction contracts requiring the payment of building trade wage rates with no kick back (even in areas where there were no trade unions left), and in general undertook to stop the construction deflation and get people back to work.

At that time I mentioned to a banker friend of mine that they were missing the one glorious opportunity to break the back of the building trades and he said: "Don't you realize if you break the building trades, we bankers have no yardstick for financing building construction? We must have stabilized costs if we are to participate in any important way in construction work. Furthermore, the government can't use our money to finance construction if the values created dissolve into thin air by further reduction of labor costs and liquidation of contractors. The building trades unions are a necessary and vital part of the construction industry and *must be maintained.*"

So it was decided by the bankers who still had money in 1932 that the building trades and their rates should be maintained, that honest competition of contractors was fine, but that bid shopping was not. And in order to stretch a little work a long way, all labor saving devices were prohibited—by government, not by union control. I recall one job where materials were dumped on the far side of the project so they could be moved by hand to the point of work. There are no significant restrictions on the use of labor saving equipment now and those few that remain will be dropped as soon as the building business gets going and can use all available mechanics.

Right now there is unemployment in the construction trades in some areas. Jobs are shut down for lack of materials. One builder I talked to recently had contracts for 30 houses, 10 under construction but all stopped for lack of materials, and 20 he couldn't start for the same reason. The building trades are not striking, did not strike during the war, and have set up machinery to adjust disputes (both internal as to jurisdiction and external as to wages and working conditions). The building troubles right now are due chiefly to material shortages; with all the fuss and furore about strikes in automobile, steel, meatpacking, electrical, telephone, railroad, coal, and other industries it seems only fair to shout from the housetops, "The building trades have not been on strike."

Apprentice Training

The trades have started a very fine apprentice training program. Servicemen are gladly accepted and each contractor is doing his best to expand his organization with these apprentices and returning skilled journeymen. Over 1000 apprentices have been taken into the Cleveland trades in the past six months. B. C. Courtwright, principal of the Cleveland Trade School, said in the Plain Dealer of February 11, "The increase in apprentices indicates a trend that may break one of the most critical bottlenecks here in the construction industry where a housing shortage exists mainly because of lack of skilled labor and materials. As a result of the increase of apprentices, promoted by a concerted effort of the Cleveland Board of Education, the Building Trade Employers Association and the AFL building trades unions, the school system has had to enlarge its facilities and has opened the old school annex as an extension."

The trades expanded at many points during the war—for example, over 10,000 steamfitters on one project. These trades are very flexible and can expand as rapidly as the building materials become available. So here again there is no artificial restraint of labor. Get the factories and mills back to work making building materials, and the building trades will carry on the postwar building program just as they did the war plant and housing building assignment.

Material Costs in Line

Costs of material are higher than they were in 1939 but the Bureau of Labor Statistics released not long ago a study showing material costs are not out of line compared with other costs. Lumber was the worst, having gone up 75 per cent, but many materials—including heating and plumbing fixtures—had risen only 10 to 15 per cent. The average of all materials was 32 per cent, which is in line with other cost increases.

For example, a standard V-8 Ford four-door sedan started at the price of $590 in 1932. In 1937 it was $759; in 1940, $808; 1942, $930; May 1, 1946, $1004; and applications are in now for further price increases. These prices are f.o.b. factory without taxes and without accessories. The delivered price right now would be nearer $1200.

When you are discussing prices, two things must be kept in mind. One is actual increase in cost on identical materials and the other is increase in cost due to improvements. Present-day automobiles are better cars than they were in 1932. Houses are likewise better—better plumbing, better heating, better electrical work. Practically all homes are insulated now. Thus, when we compare prices, if we're going to be fair, we must cut out those increases due to actual improvements—due, if you like, to customer demand. From the above I can't see that the building industry has increased its cost much more than other progressive industries, even the much-quoted automobile industry.

We hear many unsubstantiated statements about limitation in work output per man, and the favorite one is the old crack about "800 bricks per day." I have been unable to trace down any authentic cases where actual rules have been laid down as to work output. I have seen a recent account of a contractor who has been stopped from paying premium wages to his building trades, although he claims by paying a little above the scale he can increase output and reduce cost. His claim is $1400 saving on a $7000 house!

Building trade wage rates were originally considered minimums and before wage stabilization it was permissible and common practice to pay the better men something above this minimum wage. Some men work faster than others and some will work faster for more pay; hence, piecework in manufacturing. If the present trade wage rates are to be considered not only minimums but maximums, then it is going to be hard to reward the more efficient workers.

Management has been too prone to blame the sins of poor planning and supervision on the alleged restrictions in output by union rule. Let's get our planning better done. The worker wants a good boss and a good day's work. Sure there are exceptions—but over a period of 25 years I've seen and worked with a lot of trades and I submit this general statement: The building trade mechanic is inherently honest and industrious and *resents* waste of time and materials.

The Austin Co. has printed a chart showing the comparison in industrial building cost since 1913. Using 1926 as the base at 100, costs were 150 in 1920, dropping back gradually to the base and then tapering off to 90 in 1929. By 1932 this cost had crashed to almost 60 (and again I emphasize the fact there was no building even at these deflated levels). Costs climbed slowly to about 90 in 1937, fell a little in '38-'39 and then firmed up during the past six years to 130.

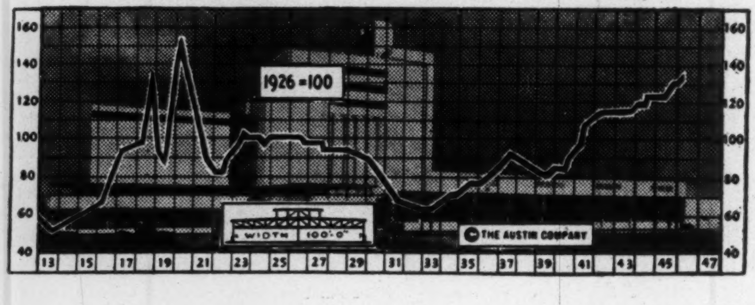
G. A. Bryant, president of Austin, says: "Persistent demand for speedy completion of manufacturing facilities in the face of increasing costs reflects industry's determination to meet the bogey of rising labor rates by improved methods, products, and efficiency. There is no use deceiving ourselves about costs, but high as they are who can say they may not go higher?" President Truman has appointed Wilson W. Wyatt as housing expediter to spur the building of 1,200,000 homes in '46 and 1,500,000 in '47; this to be implemented by various aids and subsidies. The National Association of Real Estate Boards proposed a six month holiday of federal building restrictions and a direct subsidy of $500 to $1000 to needy veterans to help them pay increased cost of housing. Why are these shots in the arm necessary? Increased costs have not killed the market. We do not need federal subsidy. We do need materials.

Prefabricated Housing

The Wall Street Journal recently carried an article on prefabricated housing and said that the CIO was going to set out to organize the building trades so that they would install the prefabrications. Chaos on chaos. Do we want housing or interminable labor troubles? "A plague on both your houses." Right now the construction industry with government and labor and finance should work out a scheme which is acceptable to all. One solution is for CIO to continue in the shops where it is now established in manufacturing, but set up separate shops for assembly of parts by AFL trades.

Carry this one step further and establish a lower wage rate *in the shops* for AFL mechanics, which would compare with shop rates in other industries, as you would eliminate the seasonal unemployment due to weather. The building trade journeymen rates of $1.75-$2.00 an hour are predicated on a 1600 hr work year. In the shops you can get 2000 hr per year and AFL shop labor should be in the general range of other labor, namely $1.25 to $1.50 per hr. If you could figure out a fair plan for an annual wage in construction work you would indeed be a great leader!

INDUSTRIAL BUILDING COSTS



Life, Time, and other critics have not suggested the one constructive step which can and will come in the AFL building trades. That is the combination of several trades into one general trade, such as the United Association of Journeymen Plumbers and Steamfitters of the United States and Canada. This organization has handled the jurisdictional problems of these several trades for many years, and is gradually getting to the point where there will be only one union for men working with pipe.

The men working with trowels could similarly combine, as could the saw and hammer trades. Twenty-three building trades could be streamlined down to six or less, with separate skills under subgroups but all in one union, and a man who was skilled enough to work with more than one kind of tool would not be fenced in by his particular union. This is not an easy problem—even if you agree it should be done—but management and labor could well start studying the possible plan and its implementation.

What Manufacturers and Owners Can Do

Manufacturers should sell only to people who will pay. The industry should not have to pay the manufacturer a premium for the materials paid for to make up for the materials not paid for. We have been spared this tribute during the past few years, so let's not go back to it. Freeze out the contractor who does not pay for materials.

And owners should not waste so much of the contractors' time in bidding work which does not go ahead. Competition should be selected and limited. Why pay for 20 or more bidders on one job? The owner should limit the bidding to a few reliable contractors and give the job to the low bidder. Or else he should not pretend to get competitive bids at all. The fee basis of work so common during the war is fair to both owner and contractor and will keep ultimate costs to a minimum.

Before we drop this subject there is one other characteristic of the construction industry that the laymen—and the curbstone critics—do not understand. The contractor maintains skeleton supervisory and engineering organization only. The mechanics do not work on a steady basis. On open building the weather may stop work. Maybe another trade delays your trade. There may be a lull between jobs. So the mechanics float from job to job, and only a few of them stay steadily with one employer year after year. A contractor can expand his force over night, providing the mechanics are available. This is not an efficient system but is the direct result of competitive bidding. If you don't like it you must then discontinue competitive bidding, negotiate your contracts, and limit the volume to the work a contractor can do with his *steady* employees. This would surely be a revolutionary step.

"A contractor can expand his force over night, providing mechanics are available"

The construction industry is a great industry and we should not have to say it is an honest one. Maybe we need some common promotion publicity such as the American Meat Institute, or the electrical manufacturers' organization, or the utilities organization. Maybe we need a good public relations program. Probably we need a little housecleaning, too. But above all we need materials and we need people—good, honest people—to come into the industry to help build all these homes and hospitals and factories and hotels and theaters and apartments and stores and other structures.

We can take full responsibility for our errors and will do as well as other industries in mending our ways. Please let the writer or speaker who calls us conniving contractors and cheating labor unions take a little time to find out what the industry is and how it works. If he can, let him present some rational plans for improvement and then *go to work* to try to get those plans accepted by the people and organizations directly concerned. It can be done!

WANTS DATA ON REFRIGERATION STORAGE

THE EDITOR—Before the war in the Pacific broke out I worked as an engineer in Java and was a subscriber to Heating, Piping & Air Conditioning. Now, being back in Holland after many years of prisonship in Japan, I should be very glad to receive Heating, Piping & Air Conditioning again. Due to the money restrictions, however, it is not possible for me to send you any money from this country at the present time. Do you know a way out of this problem?

I am very interested in the problem of ice accumulation for air conditioning purposes and I am sure you published an article about this subject in the October or November 1941 issue. Is it possible for you to send me this publication and have you any other data about this subject? I have lost all my books and study material, destroyed by the Japs, and therefore it is sometimes very difficult for me to get some data.

I am thanking you in anticipation for your kind cooperation in this matter, and I shall be very glad to receive your answer about the subscription.—P. B.

[Copies of William Goodman's articles on storage tanks for cooling systems where compressor capacity is less than load, and piping and control for storage air conditioning, have been mailed P. B.]

SAM LEWIS' PAGE

The Air We Live In

ONLY THROUGH THE influence of air are the manifold processes of life possible. That is why we live in air. Air brings us the necessary oxygen by aid of which the exceedingly efficient low temperature combustion that is necessary for life can persist, and air also carries away many of the waste products that follow this low temperature combustion.

What we call "air" is an exceedingly complex gas varying in the relative proportions of its constituents. We are especially interested, however, in the oxygen and water vapor components of air.

Animals live by the chemical treatment of their food. Most of them burn up the food or fuel at a more rapid rate than is necessary merely to keep them alive, and thus generate some surplus heat. Most of them have facilities for increasing or decreasing the rate at which the surplus heat is thrown away, and thus are able to maintain the established optimum bodily temperature. If a man does not burn his fuel as rapidly as may be required to maintain the necessary bodily temperature, he has a chill, and will soon be a sick man. If a man does not get rid of the excess bodily heat, following unusual exertion or too warm environment, he will have a fever and will be a sick man.

IN THIS regular feature, informal comment on heating, piping, and air conditioning matters is given by Samuel R. Lewis, consulting mechanical engineer, a member of HPAC's board of consulting and contributing editors. His remarks this month are taken from a popular Sunday afternoon lecture Mr. Lewis recently gave, which was one of a series sponsored by the Chicago Technical Societies Council at the Museum of Science and Industry in that city. Mr. Lewis spoke under the auspices of the Illinois chapter of the ASHVE.

Animals therefore have arrangements to reduce or increase the rate of heat dispersal by aid of the air and this is done not only through the lungs but also by the skin or other surfaces that can be exposed to the air. A great aid in controlling heat dispersal is evaporation of water on the skin. Evaporation of water is a change of state, a vital component of refrigeration.

Many Cooling Agents

There are many substances that may be used as refrigerants or cooling agents. They operate most effectively by change of state. Common water is an excellent refrigerant and is the one employed extensively by nature as an aid in controlling bodily temperature. If we make water cold enough it changes state from a liquid to solid ice. Water can be cooled to 32 degrees and then commences to change state to ice, a solid, and it cannot become any colder than 32 degrees until the heat involved in the change of state all has been removed. Water can be heated to 212 degrees, but no matter how much heat is added the water cannot become any hotter than 212 degrees, at atmospheric pressure, until it has all evaporated or changed its state to steam.

The steam or water cannot become any hotter unless it is confined in a pressure vessel, and subjected to further heat.

Ice, if invited to change its state artificially by contact with salt (as in an icecream freezer), must receive from somewhere the heat necessary to permit the change of state. It absorbs the heat from the cream, freezing the latter.

Steam, which is water changed in state by heat to a gas, if permitted to expand and partly to change its state—as in an engine—gives off some of the heat which appears as the work done by the engine, with a residue of exhaust steam which is already changing state back to the original water.

Water applied to the skin of one's hand and held in a stream of ordinary air, partly changes state from liquid to gas and the wetted spot on the skin feels cool. If one pumps up a bicycle tire by manual labor the pump becomes warm, this heat partly being due to the partial change of state of the air. Air compressors used in industry require heat removal by water jackets or by fins exposed to moving air so that the surplus heat may be removed or otherwise the compressors become too hot for adequate lubrication.

Engineers who operate compressed air locomotives, as in mines, usually have oil stoves to aid them in keeping warm, so great is the heat absorption from the surrounding air in changing state of the exhaust air from the frost covered locomotive cylinders.

Water Vapor in Air

An exceedingly important component of the air in which we live is water vapor. This vapor is simply low pressure steam that is invisible at ordinary temperature. We call the moisture component "humidity", or dampness.

If the air is carrying all the moisture it can hold, we say that the relative humidity is 100 per cent. If there is more moisture floating around than this 100 per cent that the air can carry, there will be fog. Clouds floating above the earth are the same thing as fog. The amount of water vapor that the air can carry varies with the temperature of the air. The relative humidity that was perhaps 50 per cent at a warm noon becomes 100 per cent in the cool evening and the grass and the leaves on the trees, and the insects, receive a beneficial drink.

If one rises early in the morning, the ponds and lakes seem to be boiling as the fog falling out of the air drifts down to rejoin the relatively cool water.

The frost on roofs and sidewalks s simply frozen dew and this ice an be seen to change state to iquid and then to evaporate and oin the air as soon as the radiant nergy of the sun gets a chance t it.

The constant ebb and flow of vater vapor into and out of the ir we live in persists in winter as vell as in summer. Even in the ousehold refrigerator the moisure from the food is carried by the irculating air to the ice trays and reezing compartment. There isn't ny carrier to deliver the considerble amount of water from the ood in a refrigerator to the cold urfaces and to form the ice that has periodically to be defrosted, xcept this same air that we live in.

A dog has little water glands on his tongue and on his nose. The blood carries water to these glands. The dog runs or becomes otherwise warm. Out goes his tongue so that his breathing and his running may bring lots of air to pick up this water. The good old change of state from a liquid to a gas then goes to work, and the dog's tongue and nose cool down rapidly.

A man, unlike the poor dog, has a very large area of water glands all over his body. If the man runs too fast or works too hard his blood carries water in great quantities to these glands, and he perspires. Then, if the air is not at 100 per cent relative humidity, and if the man can get in a breeze, a change of state of the water occurs and it enters the air as steam and the man cools down rapidly.

HEAT PUMP HAS PROCESS USES

REVERSE CYCLE refrigeration—the "heat pump"—has a number of industrial applications, including evaporation and distillation, reclaiming waste industrial heat, providing simultaneous heating and cooling for process air conditioning, etc., according to Philip Sporn, Theodore Baumeister, and E. R. Ambrose in a paper given at the Midwest Power Conference.

One example was mentioned where the cost of a million Btu's with direct electrical heating was 29c; with a heat pump having a coefficient of six, the cost of this amount of heat would be 4.8c. An interesting installation in Europe uses condenser water from a steam turbine in a power plant as the source of heat for the heat pump.

READER ASKS

Should We Convert a Church Heating Boiler to Burn Oil?

WE HAVE been asked by a reader of HPAC, in connection with a good sized steam heating plant in a church, whether the saving in cost of operation of a boiler designed especially for oil fuel would justify throwing out the existing cast iron sectional boiler equipped with an oil burner. The questioner thinks that heating boilers for oil fuel are radically different than heating boilers for coal.

There may be available somewhere a record of fuel oil consumed during one year in a cast iron sectional boiler, and a record of the oil burned the next year in an internal furnace steel boiler carrying the same load. I have no exact comparison. If I had such a record, however, and if it showed favorably for the internal furnace boiler, I would still not be satisfied without investigating the physical character of both boilers.

Heat Absorbing Surface

Experience and the trade literature concerning boilers go to show that almost any kind of boiler in which coal can be burned efficiently will do a good job burning oil. Many a sectional cast iron boiler, however, is so deficient in heat absorbing surface in relation to grate area that it fails to extract a reasonable amount of heat from the products of combustion before losing them up the chimney. Such a boiler would be wasteful with oil for the same reasons if operated at the same output as with coal.

There are many steel boilers with internal furnaces having so little combustion chamber diameter that coal cannot be burned efficiently, even though there may be ample secondary heat absorbing surface. In some of these boilers it was found possible by mechanical atomization and forced air supply to burn oil with more satisfactory results than had been possible with coal.

Experience in the Navy also demonstrated the increased output that could be obtained from marine type boilers having round internal furnaces when oil was substituted for coal.

Before answering this question finally, an engineer should see the old boiler to check its rating in relation to its duty, should know the type of oil and oil burner suggested for it, and should know the type of new boiler alleged to have been designed for oil alone, and proposed to replace the old one.

General Trend

The characteristics that make for economy in a heating boiler that burns coal are so like those that make for economy in burning oil, that the general trend of the industry is not to make a sharp distinction.

In large power boilers there is generally no serious difference in combustion chamber design between that for coal and that for oil. An increase in the radiant heat absorbing surface in the combustion chamber walls when coal is to be employed in such boilers is generally desirable.—SAMUEL R. LEWIS, consulting mechanical engineer and member of HPAC's board of consulting and contributing editors.

CHARACTERISTICS OF

SUMMARIZED FROM

PERCENTAGE COMPOSITION OF EARTH'S ATMOSPHERE BY VOLUME

Nitrogen	77.77
Oxygen	20.86
Water Vapor	0.41
Argon	0.93
Carbon Dioxide	0.03
Hydrogen	0.00005

Composition practically constant
with altitude up to 30 miles
except for water vapor

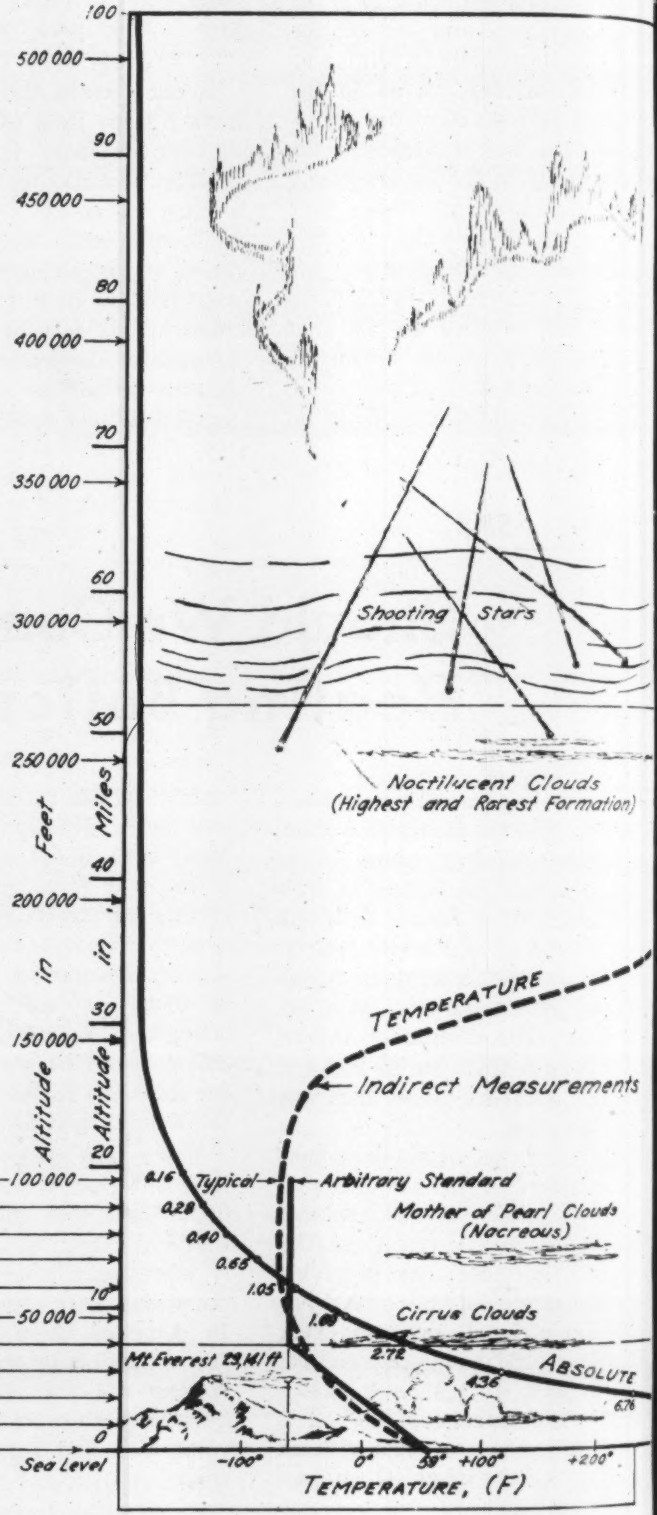
CHARACTERISTICS OF UPPER ATMOSPHERE UNDER MOST PROBABLE CONDITIONS

Altitude in Feet	Altitude in Miles	Weight of Air in Lb per Cubic Foot	Mean Free Path in Inches	Molecules per Cubic Inch
500 000	94.6	——	370.	$43.\times10^{11}$
450 000	85.2	——	65.	$25.\times10^{12}$
400 000	75.8	——	12.	$15.\times10^{13}$
350 000	66.3	0.2×10^{-8}	1.9	$84.\times10^{13}$
300 000	56.8	2.6×10^{-7}	0.3	$48.\times10^{14}$
250 000	47.4	*2.9×10^{-6}	5.8×10^{-2}	$27.\times10^{15}$
200 000	37.9	1.6×10^{-5}	1.0×10^{-2}	$16.\times10^{16}$
150 000	28.4	9.5×10^{-5}	1.7×10^{-3}	$96.\times10^{16}$
100 000	18.9	0.00107	2.7×10^{-4}	$62.\times10^{17}$
50 000	9.5	0.0116	3.6×10^{-5}	$47.\times10^{18}$
0	0.0	0.0765	†3.5×10^{-6}	‡$44.\times10^{19}$

* 2.9×10^{-6} = 2.9 pounds per million cubic feet.
† 3.5×10^{-6} = 3½ millionths of an inch between molecular collisions.
‡ 44×10^{19} = 440,000,000,000,000,000,000 molecules per cubic inch.

ARBITRARY STANDARD ATMOSPHERE FOR 45 DEG LATITUDE.

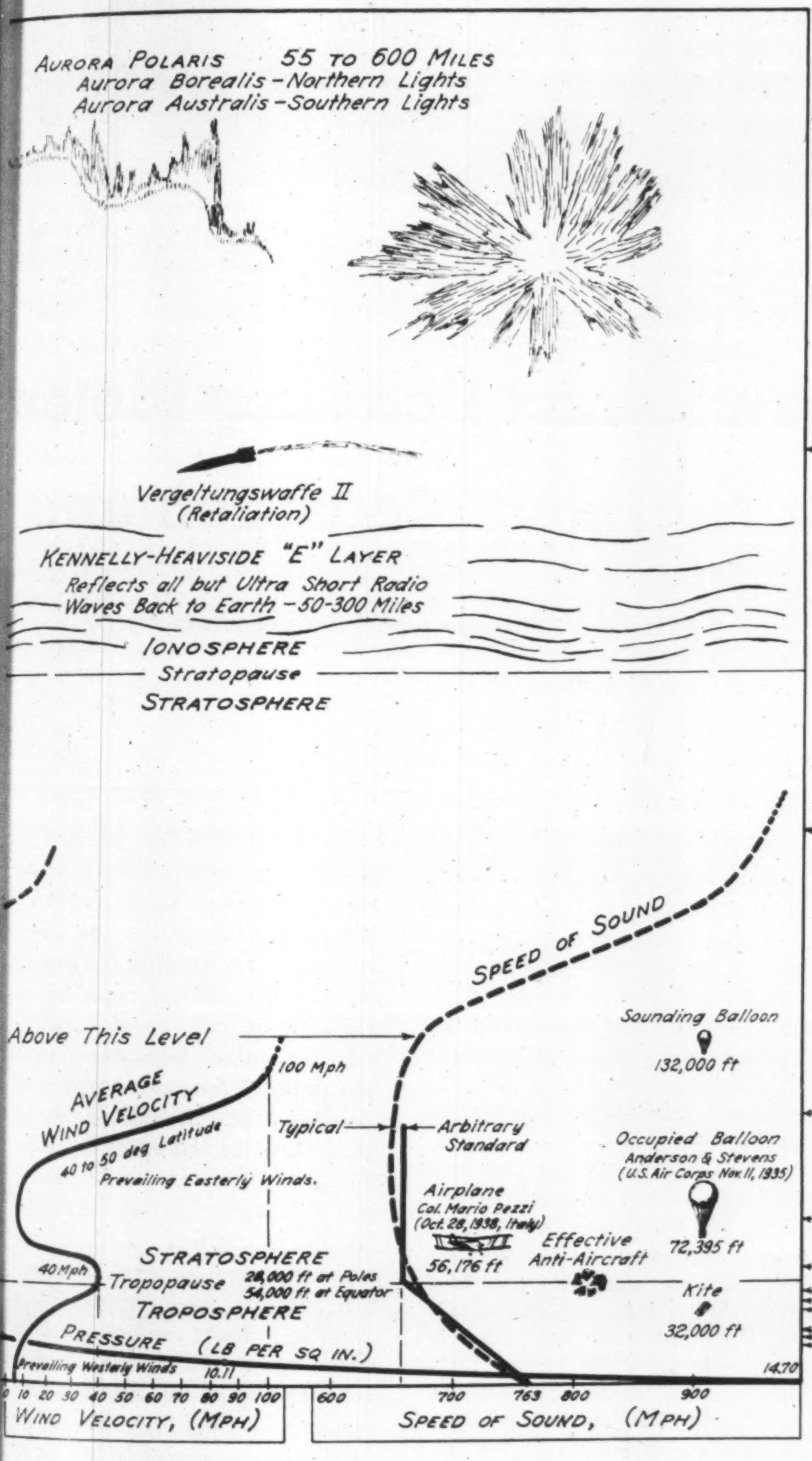
Altitude in Feet	Speed of Sound (Mph)	Ratio of Altitude to Sea Level Densities	Pressure (Lb. per Square Inch)	Temperature F	Temperature C	Weight of Air (Lb per Cubic Foot)
100 000	664	0.014	0.16	-67°	-55°	0.0011
90 000	664	0.023	0.28	-67°	-55°	0.0017
80 000	664	0.036	0.40	-67°	-55°	0.0028
70 000	664	0.058	0.65	-67°	-55°	0.0044
60 000	664	0.094	1.05	-67°	-55°	0.0072
50 000	664	0.152	1.69	-67°	-55°	0.0116
40 000	664	0.245	2.72	-67°	-55°	0.0187
30 000	680	0.374	4.36	-48°	-44°	0.0286
20 000	708	0.533	6.76	-12°	-25°	0.0408
10 000	736	0.738	10.11	+23°	-5°	0.0565
0	763	1.000	14.70	+59°	+15°	0.0765



OF THE EARTH'S ATMOSPHERE

FROM INFORMATION AVAILABLE IN 1944

From a Chart Prepared by
DOUGLAS AIRCRAFT CO., INC.
El Segundo Engineering Dept.
(Reproduced by Permission)



German V2 rocket bombs attain this altitude during flight, approximately 360,000 feet. (Reported to have attained an altitude of 160 miles in experimental vertical flight.)

Sound waves not propagated above this altitude due to increased distance between molecules.

Twilight limit. First magnitude stars are visible directly overhead when sun sets. 210,000 feet.

Maximum ozone concentration (one part ozone to 100,000 parts atmosphere.) 106,000 feet.

Blood boils at body temperature. 98.6 F. 63,000 feet.

100 per cent oxygen needed for sustenance of life. Exact altitude depends on individual and exposure. 40,000 to 45,000 feet.

Breathing pure oxygen equivalent to breathing sea level air. 33,000 feet.

Gasoline boils at normal temperature, −65 F. 32,000 feet.

Sky appears purple above this point. 30,000 feet.

Candle no longer burns. 21,000 feet.

Highest community of human beings, Andes Mts., South America. 18,000 feet.

Oxygen required for sea level dwellers to live. Altitude depends on physical condition and duration of stay. 15,000 to 20,000 feet.

DEVELOPED FOR THE NAVY'S "INACTIVE FLEET" PROGRAM

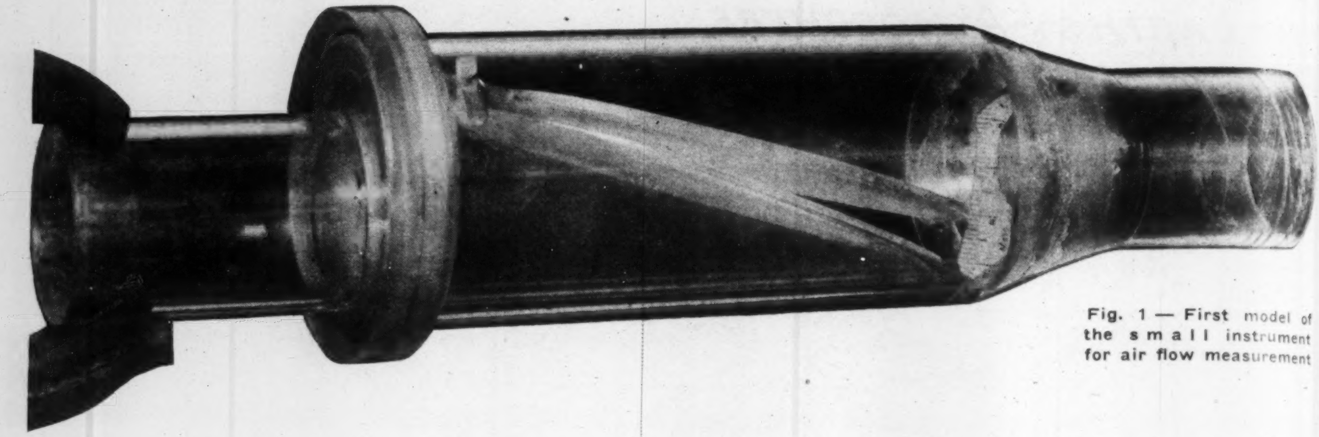


Fig. 1 — First model of the small instrument for air flow measurement

New Direct Reading Meter for Air Flow Measurements

By Leslie Silverman and Leon Epstein

Captain Urdahl and Commander Queer described the use of dehumidified air in preserving the Navy's "inactive fleet" in their article in the March issue of Heating, Piping & Air Conditioning. The volumes of dehumidified air discharged at each terminal are very small, usually within the range of 1 to 50 cfm, but it is important to be able to measure this air flow for the following reasons:

a) When the vessel is sealed and dehumidification is begun, most of the moisture is in the surfaces of the paint, machinery, piping, and structure. It is interesting to note that only about 1/10 to 1/30 (often less) of the initial moisture is in the air. Because of this, it is necessary to give larger spaces more air. The use of an air flow meter insures each space of its proportionate share of air during initial drying, thus shortening this period and saving power.

b) When the initial drying period is completed (that is, when the excess moisture has been removed from the machinery and structure) the volumes of air must be varied to meet the dehumidification load due to breathing and infiltration of water vapor. This load can only be determined by studying each vessel. A humidity controller and recorder is provided for each dehumidified zone, and psychrometric readings are taken to determine the spaces which need more or less air. Inasmuch as existing fire mains are usually used for dry air distribution, with almost no newly designed piping provided, it is not possible to know how much increase or decrease in air flow is caused by merely turning the valve handle in the piping system. By using an air flow meter the smallest change in air flow can be detected immediately.

Note that in (a) above the flow meter is required primarily to determine quantities of air and to balance the system initially, where-

IT IS IMPORTANT, in the Navy's ship preservation program, to be able to measure small quantities of dehumidified air. The flow meter used must be capable of measuring 1 to 50 cfm, be portable, be simple to use and require a minimum of calculations, and have less than 0.1 in. water gage pressure loss. Dr. Silverman, of the department of industrial hygiene, Harvard school of public health, and Mr. Epstein, of the Navy Department's bureau of ships, describe the development, construction features, and characteristics of such a direct reading air flow meter here. While they discuss only its use in the inactive fleet program, it has applications to many other purposes—such as indicating flow in ventilation ducts, gas pipes, air and gas machinery, through filters and air cleaners.

The opinions expressed are those of the authors personally and do not necessarily present the views of the Navy Department.

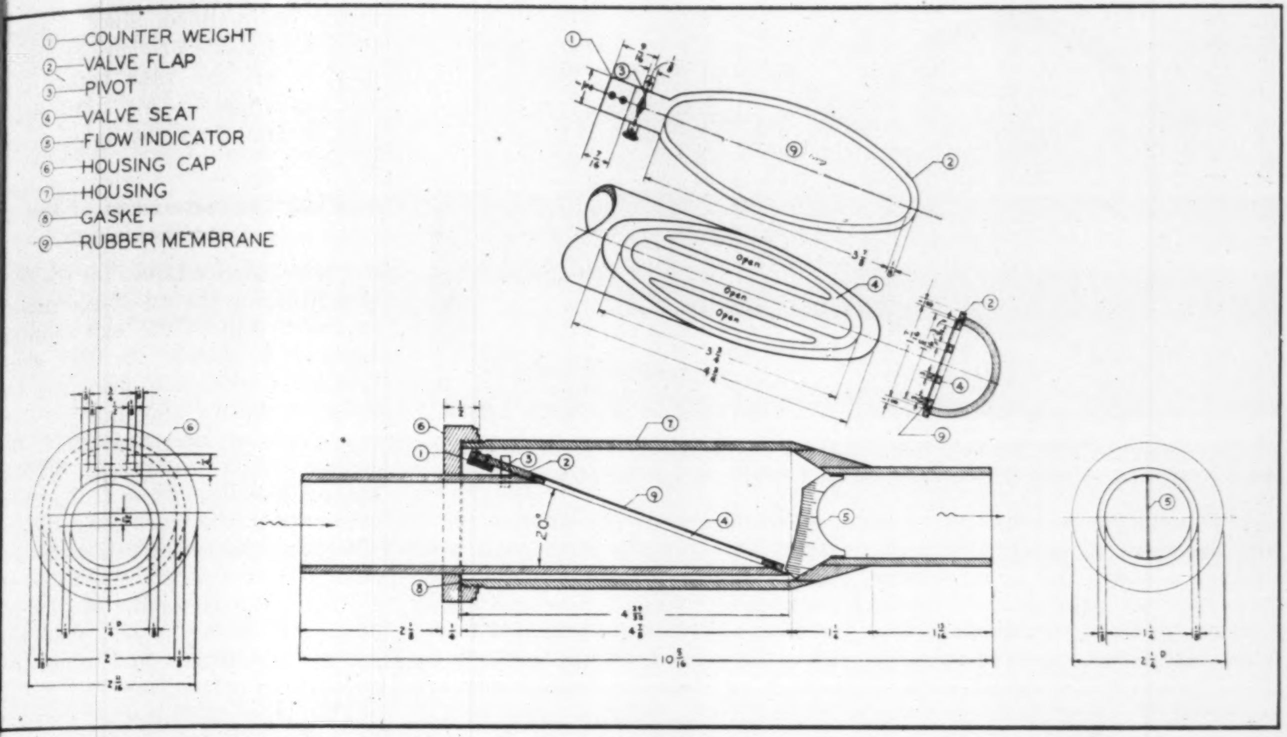


Fig. 2—Constructional details for the first model of the direct reading air flow instrument

as in (b) the instrument is required to indicate relative changes in flow and to indicate the volume for future reference.

What the Meter Must Do

The use of several experimental and commercial instruments was considered by the Bureau of Ships but only the flow meter described here was found to meet all of the following required conditions:

a) Be capable of measuring from 1 to 50 cfm of air. Most terminal discharge volumes will be within this range because very small volumes of dry air are used to dehumidify the vessels.

b) Be portable and suitable for use aboard ship. The instrument will be exposed to considerable rough handling, since it will be necessary to carry it from ship to ship, and from deck to deck within each ship. A rugged instrument is therefore essential.

c) Be simple to use and require a minimum of calculations. Most of the balancing will be done by sailors and personnel who are neither familiar with air flow measurements nor trained mathematicians. The instrument should therefore be direct reading.

d) Have less than 0.1 in. water gage pressure loss. If the pressure losses are relatively high, the flow rate will be changed with each use of the meter because the instrument is not permanently installed in the line.

Description of the Instrument

The original model of the flow indicator is shown in Figs. 1 and 2. The complete meter is made almost entirely from transparent plastic sheet and tubing (lucite or plexiglass). The instrument developed was originally designed as a low resistance breathing valve, but subsequent observations on the valve performance showed that it was an excellent flow indicator for flows from 0 to 9 cfm. This original valve incorporated the desired features of low resistance, rugged construction, and high sensitivity. It was converted into a flow meter by attaching the scale and calibrating with known air flows.

The construction details in Fig. 2 show the vane and seat as used for valve work. This vane was made from transparent plastic (lucite) and covered with a thin rubber membrane. The membrane seals against the valve seat when air flow ceases or the flow is reversed. For air flow measurements the membrane is not necessary, and a solid vane can be provided. The weight of the vane is counterbalanced by the small weight in back of the vane pivot, and this counterbalance can be adjusted to obtain the desired sensitivity of the vane. The resistance to air flow is reduced considerably by the counterbalance, but the most important factors in reducing the air flow resistance are the vane angle and surface area. The vane in resting position is at 20 deg from the horizontal, hence very little change in air flow direc-

Table 1—Air flow characteristics for original model of air flow instrument

Air Flow Cfm	Scale Deflection* of Instrument Vane Mm	In.	Resistance of Instrument to Air Flow In. of Water
0	0	0	0
1	2.4	0.09	0.024
2	5.0	0.20	0.030
3	8.8	0.35	0.035
4	13.3	0.52	0.042
5	17.5	0.69	0.061
6	21.0	0.83	0.079
7	23.7	0.93	0.106
8	25.7	1.01	0.128
9	27.2	1.07	0.158

*Deflection on arc whose radius is equal to vane length from pivot.

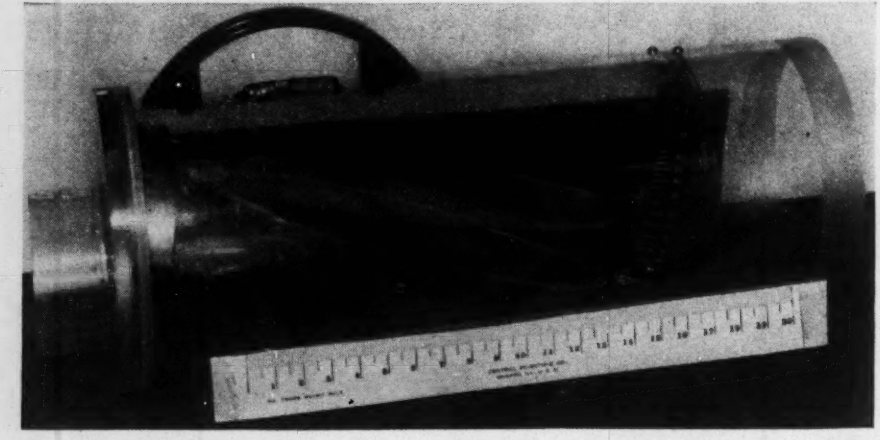


Fig. 3—Photograph of the field model without auxiliary attachments for outlet measurements. A metric rule (2.54 cm = 1 in.) is shown for size comparison

tion is required to open the vane and therefore no appreciable turbulence is introduced. Other angles were tried on experimental models, but 20 deg gave optimum results. The small angle also provides a large area for the vane surface; consequently, very little pressure is necessary to lift the counterbalanced vane.

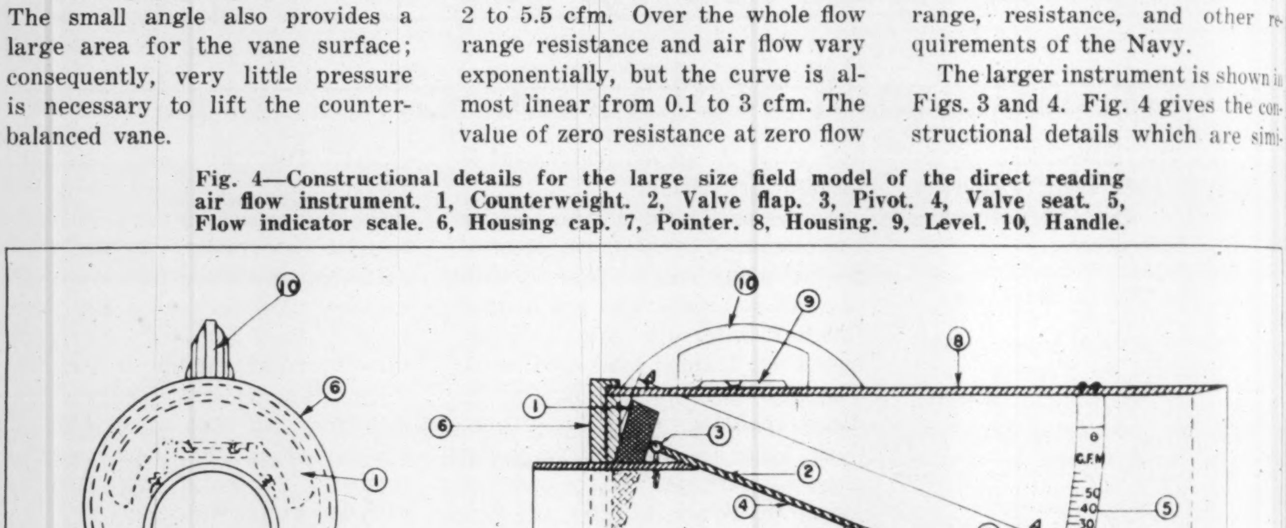
The flow characteristics of the first model of the instrument are given in Table 1. A straight line is obtained for air flow and scale deflection from 0 to 2 cfm and from 2 to 5.5 cfm. Over the whole flow range resistance and air flow vary exponentially, but the curve is almost linear from 0.1 to 3 cfm. The value of zero resistance at zero flow should be qualified, since a small amount of static pressure is necessary to lift the vane before any flow takes place. This static pressure is less than the value given at 1 cfm.

Flow Characteristics of the Instruments

The resistance values for the first model include the resistance caused by restriction of the exit opening diameter to that of the inlet, since this model was made primarily for insertion into a flow line between two tubes of the same inside diameter. The resistance is also higher because of the supporting ribs used in the valve construction. The performance of this model indicated that a larger size based on the same design as the smaller instrument would meet the flow range, resistance, and other requirements of the Navy.

The larger instrument is shown in Figs. 3 and 4. Fig. 4 gives the constructional details which are simi-

Fig. 4—Constructional details for the large size field model of the direct reading air flow instrument. 1, Counterweight. 2, Valve flap. 3, Pivot. 4, Valve seat. 5, Flow indicator scale. 6, Housing cap. 7, Pointer. 8, Housing. 9, Level. 10, Handle.



lar to those in Fig. 2, except for dimensions and an unrestricted discharge opening. A carrying handle and a level for adjustment in the field are provided. The vane is of solid plastic and no supporting ribs are necessary in the vane seat. The counterbalance weight is quite large because of the vane weight and the relative moment arms from the vane pivot. This counterbalance is made in the form of a horseshoe; the large surface of the weight thus acts as an air damper and reduces the effect of pulsation on air flow readings.

The vane pivot consists of a stainless steel pin which fits into a machined hole in the vane and a supporting yoke. Field use has shown that the vane is weakened by the drilling and requires reinforcement for rough handling. The new models now under construction will be reinforced at this section. This simple pivot with gravity counterbalance is rugged and will withstand considerable abuse and handling. The pivot is the only bearing surface, so that little friction is introduced. Another factor which reduces friction and inertia effects and gives reliable calibration over long periods of use is the absence of any fast rotating parts.

The housing for the vane is removed by unscrewing the threaded joint at 8, Fig. 4, if it is necessary to inspect the pivot. The pivot can be readily observed through the transparent plastic. Field use has indicated that the needle pointing to the scale is not necessary and that more graduations are desirable on the low end of the scale (less than 20 cfm.).

The flow characteristics of the instrument are shown in Fig. 5; this curve can also be approximated by two straight lines, one line being fitted from 0 to 15 cfm and the other from 35 to 65 cfm. The first straight line appears to fit the range of air flows in which the weight of the counterbalance is greater than the effective pressure of the air flow which lifts the vane, since the counterweight is adjusted to keep the vane seated with a slight pressure in the zero position. The change in slope of the transition section between the two straight portions of the curve is apparently the balance position in which the forces due to the counterbalance and the air pressure on the vane approximate each other. The second straight portion of the curve is controlled by the effective pressure of the air flow. By adjusting the weight of the counterbalance the point of shift between the two portions of the curve can be altered. The weight selected gives optimum characteristics for flow and resistance.

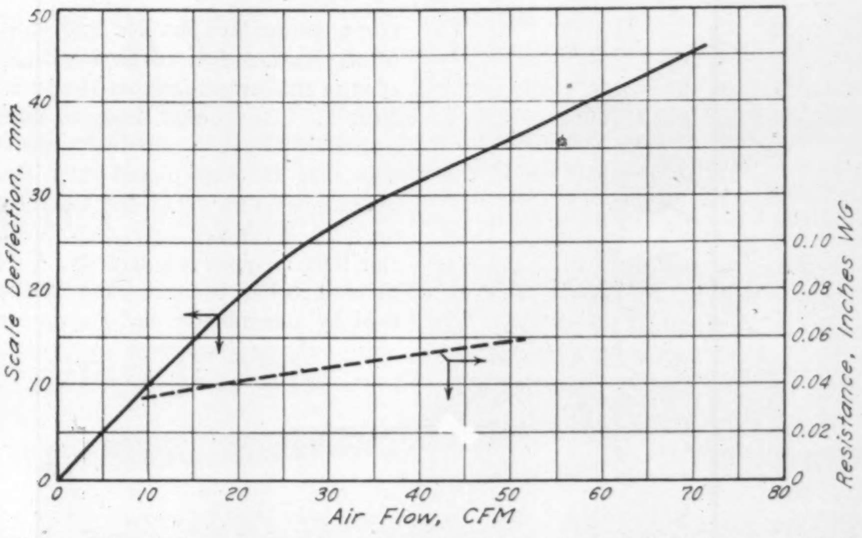
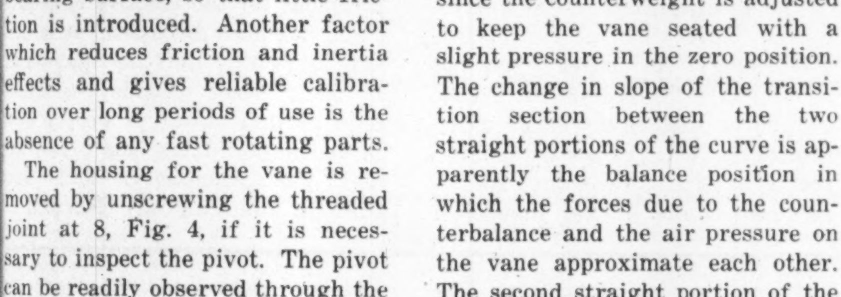


Fig. 5—Flow and resistance characteristics of the field model (25.4 mm = 1 in.)

Fig. 6—Air flow meter in use on a vertical discharge opening



An equation can be determined for the curve of Fig. 5, but derivation of an equation on a theoretical basis is complicated by the fact that the centroid of the vane shifts with the vane angularity. Another important factor which must be determined experimentally to be used in such an equation is the proportion of the velocity pressure expended in lifting the vane at various air flows. For all practical purposes, therefore, the flow curve of Fig. 5, or an empirical equation fitted to the curve data, is satisfactory for calibrating the flow scale of the indicator.

Actual flow calibration of the instrument is accomplished by means of a calibrated orifice and blower. Twenty diameters of 2 in. smooth wall plastic tubing precede the inlet to the instrument. A side tap is provided for pressure measurements. As a check, calibration was also made with a large plenum chamber preceding the instrument. In both cases, the calibrations agreed. Resistance measurements of the flow meter were made with a sensitive micromanometer. Because of the small amount of resistance present and pulsation in the air stream, these measurements are only approximate and are the maximum values noted at each flow rate. These resistance values are plotted in Fig. 5. It is evident that the resistance is negligible.

Field Use of the Instrument

Two of the field instruments have been made and used experimentally in shipboard measurements as a direct reading flow meter. The performance of these experimental units has been satisfactory and this type of flow meter, with certain

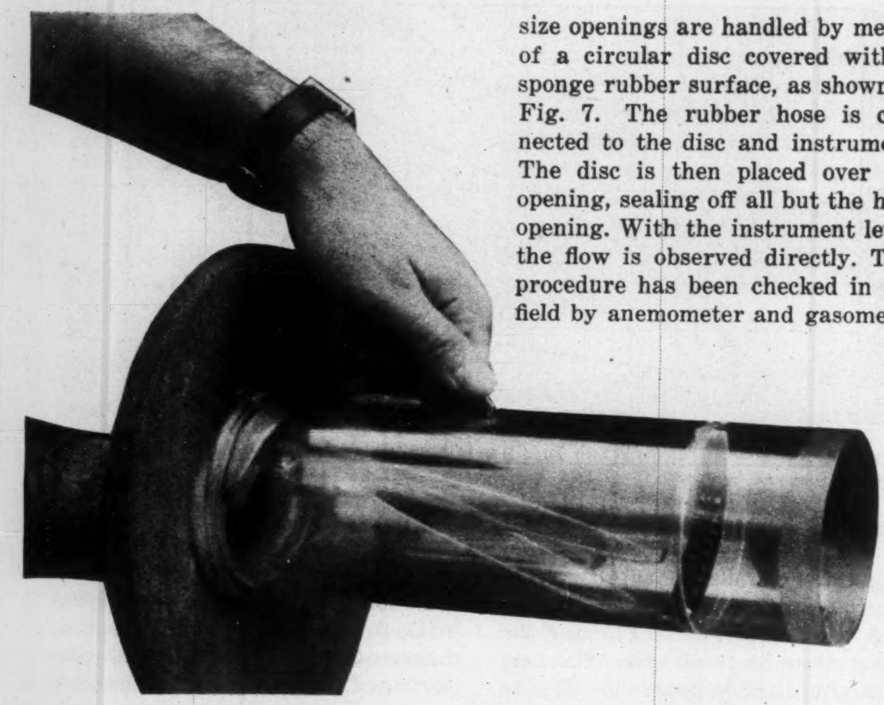


Fig. 7—Air flow meter in use on a horizontal discharge pipe opening

minor improvements, will be used extensively in the Navy's dehumidification program.

The experimental units were originally used in conjunction with a 2 ft length of smooth wall flexible hose for measurements from all but horizontal discharges, as shown in Fig. 6. For horizontal discharges this hose is not required. Various size openings are handled by means of a circular disc covered with a sponge rubber surface, as shown in Fig. 7. The rubber hose is connected to the disc and instrument. The disc is then placed over the opening, sealing off all but the hose opening. With the instrument level, the flow is observed directly. This procedure has been checked in the field by anemometer and gasometer measurements and the agreement has been within 5 per cent.

The modifications in the instruments under construction include attachments for other types of openings, a connector to permit suction as well as discharge measurements, and a means for locking the valve flap in place when the instrument is not in use. Instead of the 2 ft length of tube, a 1 ft length and 90 deg elbow will be substituted, since difficulty has been encountered in getting 2 in. hose which does not kink on short radius bends.

Use as Air Velocity Indicator

Preliminary measurements have also indicated that the instrument can also be used as an air velocity indicator. The vane will indicate air velocities as low as 100 fpm. One of the attachments being constructed for the new instruments is a bell-mouth for attachment to either end of the instrument. This bell-mouth reduces the entrance loss to the meter when it is used for velocity measurements. A taper attachment permits its connection to the large end of the instrument for suction measurements. The bell-mouth attachment can also be used for flow measurements, since it forms a small flexible flanged surface. All the attachments and fittings are of molded rubber.

Only the Navy's use of this instrument for the inactive ship program has been discussed. It is evident, however, that its application to many other uses is possible—such as indications of proper flow in ventilation ducts, gas pipes, air and gas machinery, and flow through filters and air cleaners.

PROPOSES PARTIAL DISTILLATION OF COAL

A. D. Singh, supervisor of the coal and gasification section of the Institute of Gas Technology, suggested recently a novel scheme for supplying fuel for heating, the practicality of which is indicated by work at the institute.

By partial distillation of coal, an 800 Btu gas would be obtained which could be distributed through the existing mains of the gas utility systems and would compete "favorably" with natural gas. The remaining carbon would be burned, in pulverized form, in large central stations for the generation of electric power.

PUBLISHES HOUSING ABSTRACTS

The Purdue Research Foundation, Lafayette, Ind., issued last month Vol. 1, No. 1 of a new publication—Housing Abstracts. The yearly U. S. subscription rate is $1.75. The editor is F. W. Hutchinson, well-known to readers of these pages as author of numerous articles and papers on radiant heating and other subjects.

Purpose of Housing Abstracts is to point out each month some half a hundred articles appearing in many specialized journals which might otherwise be overlooked. The abstracts are grouped under seven headings: background for the future, present housing needs, general, descriptive, legal, engineering-construction, and engineering-equipment.

PIPE COVERING OPERATIONS ON NAVAL VESSELS NOT INJURIOUS

In a paper, A Health Survey of Pipe Covering Operations in Constructing Naval Vessels, the authors, W. E. Fleischer, F. J. Viles, Jr., R. L. Gade, and Philip Drinker, state that "the character of asbestos pipe covering industry on board naval vessels is such that conclusions drawn from other asbestos industries such as textiles, cannot apply. The incidence of asbestosis among pipe coverers in shipyards studied was low, 0.29 per cent, or three cases out of 1074. Since each of the three cases had worked at asbestos pipe covering in shipyards for more than 20 years, it may be concluded that such pipe covering is not a dangerous occupation."

This paper is the result of surveys in two government navy yards and two contract navy yards during which medical examinations of the workers and a study of the nature and concentration of the contaminants in the air were made. The primary purpose of the study was to investigate the incidence and conditions, in naval construction yards, causing asbestosis.

Check INSULATION for better FUEL UTILIZATION

A VALUABLE feature of the wartime National Fuel Efficiency Program conducted in cooperation with the U. S. Bureau of Mines was the extensive series of "quiz sheets" containing tips on methods of conserving fuel in the use, operation, maintenance, and repair of various items of piping, heating, and air conditioning equipment. Because fuel conservation—a wartime and postwar necessity—is always good business and sound engineering, HPAC is publishing the information from these sheets. Practical pointers on building insulation, and use of records, are given this month.

1) Has the attic or roof been adequately insulated?

From the standpoint of fuel saving, buildings with attics or suspended top floor ceilings should have not less than 3 in. of fill or blanket insulation or equivalent, at the ceiling preferably with venting of space above to the outside atmosphere. Buildings having no attics or air space should have roof deck insulation installed to lower heat losses. In commercial buildings, working conditions are generally improved by the installation of adequate insulation. In apartment, hotel, and office buildings additional summer comfort and better rental income may supplement savings to owner through reduction in heating costs. See Table 1 for typical values of possible savings of heat loss through roofs and ceilings.

2) Are walls, cold floors and cold partitions adequately insulated?

Check construction of side walls, floors over unheated spaces, and partitions between heated and unheated spaces to determine practicability of insulating for fuel savings and comfort. If of hollow construction (wood frames or deep furring strips on masonry), recommend complete fill of insulation installed by pneumatic process. Otherwise consider surface application of suitable board type insulation in maximum thickness that construction will permit. See Table 1 for typical values of possible savings of heat loss through walls and floor.

3) Are window and door frames caulked to reduce air leakage?

All openings in outside walls should be examined for air leakage between frames and masonry or other construction. Caulking with a suitable compound greatly reduces air leakage and also adds to weather resistance.

4) Are windows and doors weatherstripped?

Use of a good quality of weatherstripping reduces the infiltration of cold air and drafts; thereby conserving fuel by reducing the heat requirements.

5) Are windows double-glazed or provided with storm sash in winter?

Though the area of glass is usually small compared to wall and roof surfaces, the loss of heat through glass is high per square foot. This loss through the glass alone can be cut materially by adding storm sash or compound glass.

6) Are entrance doors of revolving type or building entrances equipped with vestibules?

Public entrances admit excessive cold air, and induce vertical drafts through stairwells and elevator shafts in tall buildings. Best protection is by the use of revolving doors or a double set of doors in the vestibule. In some buildings, interior stair hall doors should be used.

Table 1—Typical heat losses and heat savings possible through use of insulation
(Data from Heating, Ventilating, Air Conditioning Guide)

Area	Construction	Heat loss in Btu per sq ft per hr per F				Percent heat loss saved
		Without insulation	With insulation	Thickness of insulation	Saved by insulation	
Roofs	Metal without suspended ceiling	0.94	0.24	1"	0.70	74
	Metal with suspended ceiling	0.46	0.19	1"	0.27	59
	Metal with suspended ceiling	0.46	0.08	3"	0.38	83
	4" concrete without suspended ceiling	0.72	0.23	1"	0.49	68
	4" concrete with suspended ceiling	0.40	0.07	3"	0.33	82
	4" concrete with suspended ceiling	0.40	0.06	4"	0.34	85
	1" wood without suspended ceiling	0.49	0.20	1"	0.29	59
	1" wood with suspended ceiling	0.32	0.07	3"	0.25	78
	1" wood with suspended ceiling	0.32	0.06	4"	0.26	81
Side Walls	12" solid masonry—no plaster	0.35	0.19	½"	0.16	46
	12" solid masonry—2" x 2" furring lath and plaster	0.25	0.09	1⅝"	0.16	64
	1" wood siding and sheathing, wood studs	0.36	0.06	3⅝"	0.30	83
	Stucco on metal lath, wood studs	1.16	0.07	3⅝"	1.09	94
Cold Floors	3" concrete	0.69	0.11	2"	0.58	84
	2" wood	0.34	0.07	3"	0.27	79

7) Are the heating system and domestic hot water supply system properly insulated and controlled?

Check distribution mains, storage tanks, and heat exchangers for adequate insulation of all surfaces. If any part is too hot to touch and the heat loss from the surface does not serve a useful purpose, recommend application of suitable insulation. Also check all temperature, draft, and combustion controls to see if properly installed and in operation.

8) Where may more complete information be obtained regarding fuel savings by insulation?

Consult a reliable insulation applicator for fuel savings that may be realized in your building by any of the methods discussed herein.

RECORDS AND THEIR IMPORTANCE TO FUEL UTILIZATION

1) Do you keep records?

Every plant should keep records of daily performance. To attempt to operate a plant—or, in fact, any enterprise—without a knowledge of performance is poor business practice.

2) How may fuel consumption be determined?

If you are using gas purchased from a utility company, the gas in all probability passes through a meter which may be read daily.

If liquid fuel is used it may be metered or the storage tank may be equipped with a gage, or if a gage is unobtainable it is generally possible to check the height of the fuel tank and determine the volume by referring to a table or chart of tank capacities vs. liquid levels.

The determination of solid fuel consumption is somewhat more complicated, unless the plant has suitable scales on which to weigh the fuel delivered to the boilers. Otherwise a volumetric determination may be made. This procedure naturally is not as accurate as the exact weight but if carefully computed a fairly good approximation can be made. Thirty-eight to 40 cu ft per ton is generally the unit used in calculating the weight of coal.

3) How may heat output be determined?

When steam is being generated, the usual way to measure output is by means of a steam flow meter or a feedwater meter. If neither of these is available and the pump is of the reciprocating type, the approximate output in a given time may be computed by determining the pump capacity and equipping it with a stroke counter. The condition of the pump and the type of service will materially affect the accuracy of this method.

If the fuel is being used in an industrial furnace or kiln, the fuel can be calculated per ton of product treated.

4) Do you check the evaporation and the fuel-power ratio?

After the fuel consumption is known and the steam output recorded, a steam-fuel ratio can be established. A drop in this ratio often indicates a drop in efficiency and may be due to any one condition or a combination of many conditions, such as a dirty boiler, excessive air for combustion, poor firing practice, etc.

Likewise it is imperative that an accurate check be kept of the fuel used per kilowatt generated. An increase in this ratio may indicate a faulty engine or turbine, poor vacuum, too much back pressure, etc.

Ratios calculated daily may show considerable fluctuation in some plants using solid fuels unless accurate estimates are made of the amount of fuel in hoppers and on grates. For these plants, ratios calculated on a weekly basis may prove to be more useful.

It is advisable where possible, to check your fuel-power ratio with other plants of similar design and size, operating under comparable conditions, to determine how your performance compares with that of the other plants. If the fuel-power ratio in your plant is appreciably higher than the average, ways and means should be considered for improvement of plant performance. By so doing you will not only save fuel, but dollars as well.

5) In space heating, what is a practical way of checking fuel consumption?

The amount of fuel used to heat a structure for one day should be about proportional to the number of degree-days of heating required on that day. The number of degree-days for a given date is equal to the difference between 65 F and the daily mean temperature in a given area, recorded by the U. S. Weather Bureau, and usually reported in the local newspapers. The total degree-days for a normal heating season in a given area can be obtained from the U. S. Weather Bureau—a ratio of the daily degree-days to the total degree-days can then be computed. Then multiply this ratio by the normal year's fuel consumption to determine what the daily fuel consumption should have been for that day.

6) Do you keep log sheets of plant performance?

In addition to checking fuel consumption against heat delivery, it is advisable to record other phases of plant performance, such as flue gas temperature, feedwater temperature, flue gas analysis, steam pressure, draft, windbox pressure, frequency of blowdown, etc.

If you are operating a large plant with auxiliary equipment, it is advisable to have a series of log sheets—that is, one for the boiler room, one for the turbine room, one for industrial furnace performance, etc.

7) Do you know that the instruments in the plant are in good condition and reasonably accurate?

Unless instruments from which log sheet data are read are maintained so that the indications are reliable, the log sheet information can be very misleading. It is essential that the best care possible be given to instruments, and that they be checked for accuracy.

8) Are log sheets examined regularly?

Log sheets should be examined carefully by someone well versed in plant operation. This insures that changes in performance of the various elements in the plant will be noticed and corrective measures carried out soon after they are necessary.

Heating, Piping & Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

The Sol-Air Thermometer—A New Instrument

By C. O. Mackey[*] and L. T. Wright, Jr.,[**] Ithaca, N. Y.

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in cooperation with Cornell University.

SUMMARY—Description of an instrument for determining directly the sol-air temperature which is the temperature in the shade that would be equivalent to the combined effect of air temperature plus sun radiation and sky radiation during sunlit hours or to the combined effect of air temperature and radiation to the sky at night.

The authors recommend installation of similar meters in several key cities for determination of the summer sol-air temperature.

Sol-Air Temperature

THE CONCEPT and the significance of sol-air temperature in the application of weather data to the estimate of summer cooling loads have been presented in three earlier papers[1]. Briefly, the sol-air temperature combines the effects of air temperature in the shade, solar radiation incident upon a building surface or net radiation emitted by that surface to a cold sky, absorptivity of the surface and wind movement. Between sunrise and sunset, when solar radiation is incident upon the surface of a building material which does directly transmit solar radiation, the sol-air temperature (t_e) for that surface is

$$t_e = t_a + \frac{bI}{h},$$

where

t_a = temperature of the air in the shade, Fahrenheit;

I = intensity of total solar radiation* (direct and diffuse) incident upon the surface, Btu per (hr) (sq ft);

b = absorptivity of the surface for such solar radiation (with values from 0 to 1);

h = outdoor air film coefficient of heat transfer by convection, Btu per (hr) (sq ft) (Fahrenheit degree)

The instantaneous rate of entry of heat into the outer surface of the material with either steady or unsteady heat flow is

$$\left(\frac{q}{A}\right)_L = h\ (t_e - t_L),$$

where

t_L = temperature of the outer surface of the material, Fahrenheit.

For example, if t_a=90 F, b=0.7, I=200 and h=4, t_e=125 F and the rate of entry of heat into the surface of the material is precisely as if the air temperature were 125 F with no radiation incident upon the surface.

Between sunset and sunrise when there may be a net transfer of radiant energy *from* the surface *to* a cold sky, the sol-air temperature is

$$t_e = t_a - \frac{I'}{h},$$

where

I' = the net transfer of radiant energy *from* the surface to surroundings, Btu per (hr) (sq ft)

For example, if $t_a = 70$ F, $I' = 30$ and $h = 3$, $t_e = 60$ F and the rate of heat transfer into the surface (or away from the surface, if t_L is greater than 60 F) is precisely as if the air temperature were 60 F with no radiant heat exchange.

The Sol-Air Thermometer

When Weather Bureau data are used to evaluate sol-air temperatures, there are many gaps in the available information. Tempera-

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[*] Professor of Heat-Power Engineering, Cornell University. Member of ASHVE.

[**] Assistant Professor of Heat-Power Engineering, Cornell University. Junior Member of ASHVE.

[1] ASHVE Research Report—Periodic Heat Flow—Homogeneous Walls or Roofs, by C. O. Mackey and L. T. Wright, Jr. (ASHVE TRANSACTIONS, Vol. 50, 1944, p. 293.)

Summer Weather Data and Sol-Air Temperature—Study of Data for New York City, by C. O. Mackey and E. B. Watson. (ASHVE JOURNAL SECTION, Heating, Piping & Air Conditioning, November, 1944, p. 651.)

Summer Weather Data and Sol-Air Temperature—Study of Data for Lincoln, Nebraska, by C. O. Mackey. (ASHVE JOURNAL SECTION, Heating, Piping & Air Conditioning, January, 1945, p. 42.)

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Montreal, Que., Canada, June 1946.

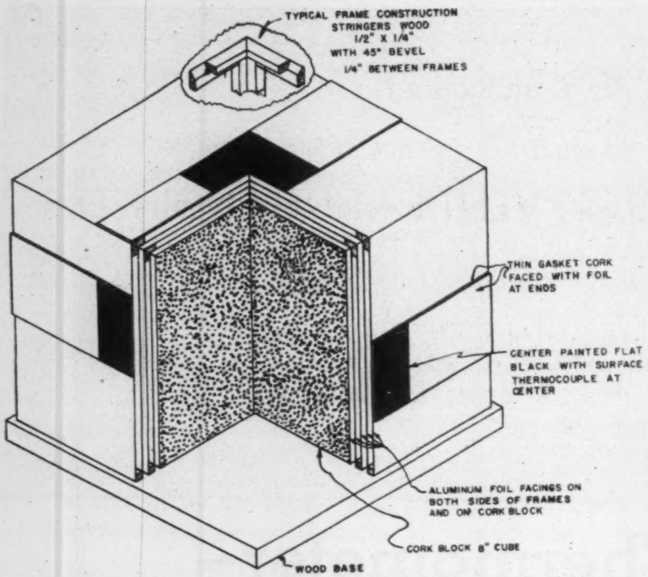

TYPICAL FRAME CONSTRUCTION
STRINGERS WOOD
1/2" X 1/4"
WITH 45° BEVEL
1/4" BETWEEN FRAMES
THIN GASKET CORK FACED WITH FOIL AT ENDS
CENTER PAINTED FLAT BLACK WITH SURFACE THERMOCOUPLE AT CENTER
ALUMINUM FOIL FACINGS ON BOTH SIDES OF FRAMES AND ON CORK BLOCK
CORK BLOCK 8" CUBE
WOOD BASE

Fig.1—Sol-air thermometer construction details

tures of the air in the shade are measured hourly; at some stations, the intensity of total solar and sky radiation incident upon the horizontal is measured; wind movement is measured. Intensities of total solar and sky radiation incident upon vertical surfaces of various orientations are *not* measured; radiant heat exchange with the cold sky at night is *not* measured; there is no attempt, of course, to measure solar absorptivities or film coefficients of convective heat transfer of various surfaces.

Lacking such data, there is an obvious need for a meter which will measure, directly, the sol-air temperature day or night. The instrument shown in Fig. 1 was devised for this purpose. The meter may have many different forms, but there are certain principles to be followed in its construction. For any exterior surface which does not directly transmit solar radiation, the sol-air temperature is the actual temperature of that surface when it is receiving solar radiation or emitting radiation to a cold sky with convective transfer of heat to or from the surrounding air, but when there is no transfer of heat *from* that surface to the interior or no transfer of heat *to* that surface from the interior. The instrument designed is in the form of a cube; resting upon the base at the center of the cube is an 8 in. cube of cork. The horizontal and four vertical faces of this cube are faced with aluminum foil; four curtains of aluminum foil are then hung from frames as shown to create four air spaces of ¼ in. width on each face. In this way, considerable thermal resistance is placed in the path of heat flow between exterior faces of the instrument. This puts each exterior face of the meter in heat exchange relationship with its exterior surroundings, only. With this arrangement, the exterior faces of the meter will assume and maintain their respective sol-air temperatures. It should be emphasized that the surfaces of a building do not assume the sol-air temperature, commonly, because of conduction of heat away from these surfaces toward the interior or from the interior toward the surfaces. The temperature indicated by the meter is not the temperature that would be assumed by a building surface, but is very close to the true sol-air temperature.

Another principle of design is that the surface of the meter should have low heat capacity in order that the temperature of the surface may respond quickly to changes in the external conditions of solar radiation, air movement, or air temperature. In the meter shown, the strips of thin gasket cork were fastened to the aluminum foil on the four vertical faces and on the top horizontal face; cork has extremely low volumetric heat capacity. A thermocouple of No. 36 copper and constantan wires was imbedded in each cork strip and the leads were carried in this cork for about 2 in. Five leads were then carried to a selector switch from the cork. A copper constantan couple to measure air temperature was hung below the instrument in the shade of the base and leads from this couple were also carried to the selector switch. In this way six temperatures may be measured with a potentiometer.

In this first instrument, a small square of the cork containing the imbedded thermocouple was painted with two coats of No. 42 Sherwin and Williams black paint which has an absorptivity approaching unity. Sol-air temperatures measured by this instrument are, therefore, the sol-air temperatures of surfaces with an absorptivity of substantially 1.0.

One of the features of this instrument, however, is that the sol-air temperatures for surfaces of different solar absorptivities may be found without actually determining these absorptivities. Thin slices of the materials in question may be affixed to the external foil and the thermocouples imbedded in these surfaces; the temperature assumed is then the sol-air temperature of that particular surface under the existing external conditions. Thus, thin slices of wood may be painted different colors and a thermocouple imbedded in each different patch will record a sol-air temperature for a wood surface painted with that color; thin slices of brick or mortar may be similarly attached; thin pieces of roofing materials may also be investigated in the same manner. This procedure also gives

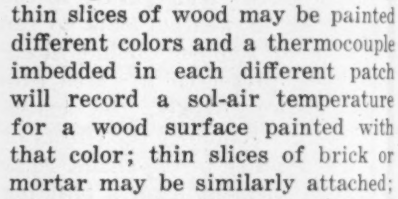


Fig. 2—Sol-air thermometer mounted on tripod

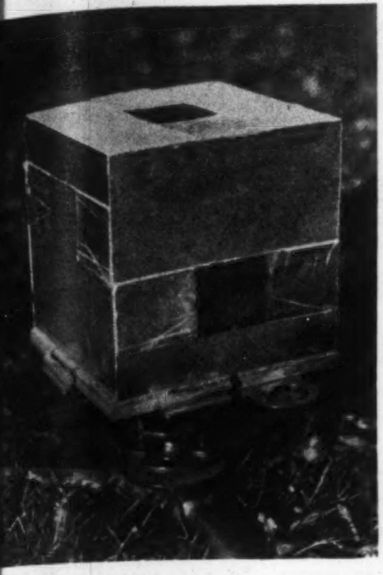
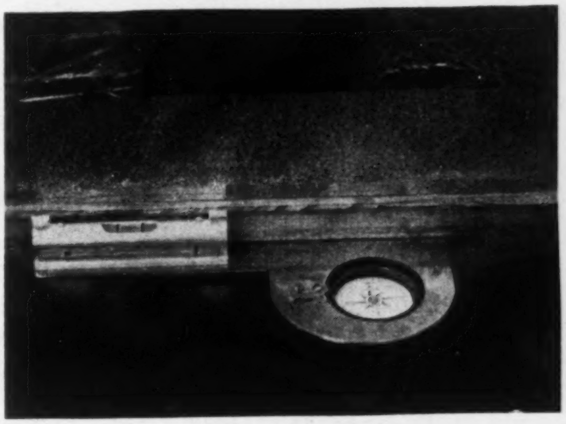


Fig. 3—Sol-air thermometer mounted on stand

Fig. 4—Sol-air thermometer—close-up view of level and compass



a method of determining solar absorptivities by proper comparison of the sol-air temperature of any surface with the sol-air temperature of a *black* surface of the same orientation; the air temperature is the only other variable that must be measured for this purpose.

The cube shown was mounted upon the tripod of a surveyor's level and two levels were attached at right angles so that the top surface could be placed in a true horizontal position and the four vertical faces in true vertical positions. A compass was included in the mounting so that the orientation of the vertical surfaces might be known. Photographs of the meter are shown in Figs. 2, 3 and 4.

Daytime Data

The meter was not completed until the fall of 1945. On a clear day, October 11, 1945, the meter was set up on the Cornell campus at Ithaca, N. Y. The vertical surfaces of the cube were oriented to face the true north, east, south and west. Temperatures of the five faces of the cube and of the air in the shade were recorded with the results as shown in Table 1.

The scale of millivolts on the potentiometer used was such that the observed temperatures are probably accurate to ±2 F.

These readings show that the meter is successful in maintaining a large temperature difference between the several faces and they also indicate that the response of the meter to changing external conditions is rapid. Observers noted a large and rapid change of sol-air temperature with changes in wind direction and speed. The readings indicate the complex nature of heat transfer in buildings caused by rapidly changing ambient conditions. For example, at noon on the day of the test, the external surface of a building with a solar absorptivity of nearly one would be *gaining* heat as if exposed to an air temperature of 92 F if horizontal and 112 F if facing south, while it might be *losing* heat as if exposed to an air temperature of 63 F if facing east, of 61 F if facing north and of 57 F if facing west; all this occurs with an actual temperature of the air in the shade of 50 F. There is a sol-air temperature for the human body, of course; on the day of the test, students without topcoats were comfortable with an air temperature of only 50 F.

Night Sol-Air Temperatures

The question of the effect of night radiation from building surfaces to a cold sky upon rate of heat transfer during the following day has been raised in several discussions of the three papers previously mentioned. Since the Weather Bureau data contained no information on this question, night sol-air temperatures for New York, N. Y., and for Lincoln, Neb., were taken equal to the observed air temperatures.

Actually, during the night hours, if the angle factor from surface to

Table 1—Top and Side Temperatures of Sol-Air Thermometer on October 11, 1945, Ithaca, N. Y.

Eastern Standard Time	Air Temperature in Shade F	Observed Sol-Air Temperatures for Solar Absorptivity of 1.0, F				
		Horizontal Surface	Vertical Surface Facing			
			North	East	South	West
11:30 a.m...	50	95	61	66	108	59
11:45	49	89	58	65	109	55
12:00 noon..	50	92	61	63	112	57
12:15 p.m...	52	97	64	63	121	66
12:30	50	88	61	59	115	66
12:45	52	92	62	59	112	73
1:00	51	87	61	61	110	78
1:15	52	90	61	56	109	82
1:30	51	88	60	57	105	84
1:45	53	94	66	65	111	94
2:00	54	88	66	61	102	92
2:15	53	86	63	61	106	96
2:30	53	82	62	61	102	97
2:45	54	79	63	61	98	97
3:00	53	76	62	59	94	101
3:15	55	76	62	61	93	107
3:30	57	74	62	61	91	101
[a]3:45	56	56	56	56	57	62

[a] Sun went under a cloud at this time.

Table 2—Calculated Design Sol-Air Temperature for a Horizontal Roof in New York, N. Y.

Hours After Noon	Sol-Air Temperature, F	
	No Night Radiation	Night Radiation to Sky at —60 F
0 (noon)	135	135
1	136	136
2	134	134
3	129	129
4	123	123
5	112	112
6	101	101
7	91	91
8	85	64
9	83	62
10	82	61
11	81	60
12 (mid.)	79	59
13	78	58
14	77	57
15	77	57
16	76	56
17	76	56
18	79	79
19	92	92
20	102	102
21	114	114
22	122	122
23	130	130
Avg.	99.8	91.2

sky is unity (if the building surface *sees* only sky), the sol-air temperature of the surface is

$$t_e = t_a - \frac{eI_n}{h},$$

where

e = emissivity of the surface;

I_n = net rate of heat transfer by radiation from a *black* surface to the cold sky, Btu per (hr) (sq ft);

$$= 0.173\left[\left(\frac{T_L}{100}\right)^4 - \left(\frac{T_s}{100}\right)^4\right]$$

where

T_L = the absolute temperature of the surface;

T_s = the effective radiating absolute temperature of the sky.

For the expected temperature of surface and sky on *clear* nights,

$I_n = 0.68\ (t_L - t_s)$ (approximately)

In order to estimate the probable effect of radiation to a *clear* sky during the night, it may be assumed that the effective radiating temperature of a clear sky is about —60 F. For a horizontal roof located in New York, N. Y., design sol-air temperatures shown in Table 2 have been calculated. The surface has been assumed to have a solar absorptivity of 0.7 and an emissivity for radiation to a cold sky of 1.0; it is assumed that the horizontal building surface *sees* only a *clear* sky at an effective radiating temperature of —60 F between sunset and sunrise. Design sol-air temperatures are given in Table 2 for each hour of the day, with and without radiation to the sky at night.

Table 3—Effect of Radiation to a Clear Sky Upon Cooling Load

	No Radiation to Night Sky	Night Radiation to Sky at — 60 F
Calculated temperature of inside surface of slab, F.	99.3	97.4
Calculated rate of heat transfer from slab to indoor air, Btu per (hr) (sq ft)................	31.8	28.7

As an example of the effect upon cooling load of this radiation to a *clear* sky at night, precise calculations have been made for one roof slab. The roof is assumed to be homogeneous with a thickness of 6 in.; the material chosen is concrete with k=1 Btu per (hr) (sq ft) (Fahrenheit degree per in.) ρ=143 lb per cu ft, and c=0.21 Btu per (lb) (Fahrenheit degree). The maximum contribution to the cooling load due to heat transfer through this roof would occur at about 4 p.m. At this hour and for the design sol-air temperatures previously reported, the temperatures of the inside surface of the roof and the corresponding rates of heat transfer to indoor air at 80 F with and without an allowance for radiation to a clear night sky are shown in Table 3.

The conclusion is that radiation to a sky at —60 F between sunset and sunrise causes a 10 per cent lower rate in the *maximum* contribution to the cooling load from a horizontal 6 in. concrete roof slab in New York, N. Y., as compared with the maximum load when no night radiant exchange is assumed to occur. In the example, a clear sky at —60 F was assumed to exist at all times between sunset and sunrise; this gives rise to a probable *maximum* reduction in cooling load, for there is no assurance that such a situation would exist in combination with the high daytime sol-air temperatures. The effect of night radiation upon cooling load would be still less for vertical walls, because they exchange heat by radiation at night not only with the sky but with surfaces at much higher temperatures such as pavement, ground, trees and the surfaces of other buildings. In other words, the night sol-air temperatures for vertical surfaces would be expected to be higher than for horizontal surfaces.

Night Data

The sol-air thermometer was set up on only one night in Ithaca, N. Y., October 22, 1945, with the readings shown in Table 4.

The night in question was clear with a full moon. As explained in

Table 4—Top and Side Temperatures of Sol-Air Thermometer on Night of October 22, 1945, Ithaca, N. Y.

Eastern Standard Time	Air Temperature in Shade, F	Observed Sol-Air Temperatures for Emissivity of 1.0, F				
		Horizontal Surface	Vertical Surface Facing			
			North	East	South	West
12:30 a.m..	42	33	38	39	39	39
12:45 a.m..	42	32	37	38	38	38
1:00 a.m..	41	31	36	37	37	37

connection with the daytime readings, these temperatures are accurate only to ±2 F. As expected, the night sol-air temperature for the horizontal surface was observed to be lower than for vertical surfaces. The maximum difference between the air temperature and the sol-air temperature for the horizontal surface in these few observations was 10 F.

Summary

The authors believe that further progress in the analysis of summer weather data, insofar as they may be applied to the estimate of cooling loads, is handicapped by an incomplete knowledge of: (1) solar absorptivities of surfaces of various building materials; (2) effect of wind velocity and surface condition upon exterior convective film coefficient of heat transfer; (3) intensity of solar radiation incident upon *vertical* surfaces; (4) radiant heat exchange between building surfaces and the cold night sky.

The authors believe that the sol-air temperature concept is the best method of combining the several variables in their effect upon cooling load. They believe that a meter which measures sol-air temperature, directly, is superior to any attempt to determine, separately, the several variables and combine them by calculation. Accordingly, they have submitted a design for such a sol-air thermometer. One such meter has been built and a few observations from its use are included.

The authors recommend that meters of this or improved design be used in several key cities in order to obtain more accurate information concerning summer sol-air temperatures.

The authors also recommend a program directed toward the improvement and calibration of the sol-air thermometer as a field instrument. The principal uses of the final meter should be: (1) to determine design sol-air temperature *vs.* time cycles for several different localities; (2) to determine the solar absorptivities of the surfaces of various important building materials.

LABORATORY TO CONDUCT THERMAL CONDUCTIVITY STUDIES

L. P. Saunders, chairman of the Committee on Research announces that a new program to provide more accurate and dependable values of thermal conductivity for most of the insulating materials on the market has been initiated by the Committee and will be carried out by the Technical Advisory Committee on Insulation.

The first step in the program, the one which is now actively under way, is the checking and accrediting of the laboratories which will do this actual testing in accordance with the new *ASTM* Code. This code (*ASTM* C177-45), which is the result of joint action of the American Society of Heating and Ventilating Engineers, *the American Society for Testing Materials, the American Society of Refrigerating Engineers* and the National Research Council, now provides a standardized testing procedure for the determination of thermal conductivity.

All of the commercial and university laboratories which are known to have hot plate equipment are being canvassed to determine whether their equipment conforms to *ASTM* C177-45 standards and whether they are willing to undertake tests to establish correlations and determine the relative accuracy of the various pieces of test equipment.

To all the laboratories having acceptable equipment and indicating a willingness to participate in the plan, the ASHVE Research Laboratory will send a sample of insulating material. This sample will be tested in accordance with the *ASTM* C177-45 Code and returned, together with test results, to the ASHVE Research Laboratory, Cleveland. The same sample will then be sent to the National Bureau of Standards, Washington, D. C., where it will again be tested. Accreditation of laboratories will be made on the basis of their ability to check within acceptable tolerances the values obtained at the Bureau of Standards.

As soon as possible a list of approved laboratories will be made available to manufacturers of insulating materials and they will be urged to have their products checked at one of the laboratories listed. It is hoped that the progress of this program will permit the limiting of *K* values for insulating materials to be published in the ASHVE Guide 1949, to those determined in accordance with this new *ASTM* Code.

The program outlined is highly desirable according to Chairman Saunders. Currently published tables of conductivity values for insulating materials indicate that they have been determined by various laboratories, at various mean temperatures and probably with various types of equipment. Also, improvement in insulating material during the past few years indicates a need for the rechecking of insulating values. In addition to insulations, many other building materials, which could be readily tested by the hot plate method, should have their *K* values redetermined. Manufacturers of certain roofing materials, non-insulating types of building board, etc., should find this program of particular interest.

Any laboratories which have hot plate equipment conforming to the *ASTM* Code and which have not received the invitation to participate should communicate at once with the ASHVE Research Laboratory, 7218 Euclid Avenue, Cleveland 3, Ohio.

R. K. THULMAN ADDRESSES IHVE IN LONDON

The members of the *Institute of Heating and Ventilating Engineers*, London, were interested in the subject presented by R. K. Thulman, Washington, D. C., at their March 20 meeting. His topic was Heating Small Houses—the Opportunity for the Engineer. While in England, Mr. Thulman also attended the institute's annual dinner on February 13. Mr. Thulman is mechanical engineer with Federal Housing Administration and is a member of the ASHVE Committee on Research.

Forced Convection Heat Transfer Coefficients Along a Flat Surface

By George V. Parmelee* and Richard G. Huebscher,** Cleveland, Ohio

This paper is the result of research carried on by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS at its Research Laboratory located at 7218 Euclid Ave., Cleveland 3, Ohio

SUMMARY—Experimental measurements have been made of the rate of convective heat transfer through a turbulent boundary layer from a smooth flat surface to a parallel stream of air. The data show the effects of air velocity and surface length and are in substantial agreement with a theoretical treatment developed from the closely related phenomenon of skin friction. A brief description of the apparatus has been given. Curves have been developed to show the separate effects of surface length and air velocity for conditions of interest to the air conditioning engineer. Calculations have also been made to illustrate the effect of surface length on the overall transmission coefficients of single and two or more air spaced sheets of glass.

Introduction

THIS report summarizes the progress of research related to the rate of heat transfer by forced convection from a vertical smooth flat surface swept by a horizontal parallel stream of air. The research on this subject arose from a need for more exact data as to the effect of wind velocity on the overall transmission coefficient of windows and was authorized by and carried on under the direction of the Technical Advisory Committee on Glass.† The data herein presented show the combined and separate influences on the convection coefficients of air velocity and surface length measured in the flow direction. They are compared, through the medium of dimensionless numbers, with the skin friction of flat plates.

The application of the data is restricted to the following conditions:

1. that the surface is perfectly smooth and flat,
2. that the air stream is undisturbed up to the point at which it first makes contact with the smooth surface, and
3. that the flow of the air along the plate is such that the velocity distribution in the layers of air close to the surface is characteristic of turbulent flow.

The results of this phase of the work, which are only briefly described in the following pages, will appear in detail in the ASHVE TRANSACTIONS for 1946. In the complete report are contained a review and correlation of previous ASHVE research on the subject, studies of the turbulence characteristics of the wind tunnel and measurements of the velocity distribution close to the surface of the plate. In addition appendices give sample computations and a derivation of the α factor.

Later reports will deal with other phases of this general problem such as coefficients for laminar flow and the effects of widely spaced ribs or fins.

Experimental Method

Fig. 1 shows the arrangement and essential characteristics of the test setup. In brief, the apparatus consisted of a smooth flat plate electrically heated and suspended in the center of a rectangular draw-through type wind tunnel. Measurement of the electrical input together with the temperature of the air and of various parts of the plate surface afforded a means of computing the unit rate of heat transfer, that is, the film coefficient, from the plate to the air stream. The length was adjustable in four steps by heating different parts of the plate. The velocity of the air could be adjusted as desired so that the effects of a reasonably wide range in value of these two variables could be studied. An important feature was the use of polished aluminum for the heat transfer surface in order to reduce radiant heat transfer to a minimum. Figs. 2 and 3 are photographs of the plate and its installation in the wind tunnel.

During the course of the experimental work both the arrangement of the plate in the tunnel and also the shape of its leading edge were altered in accordance with the following description:

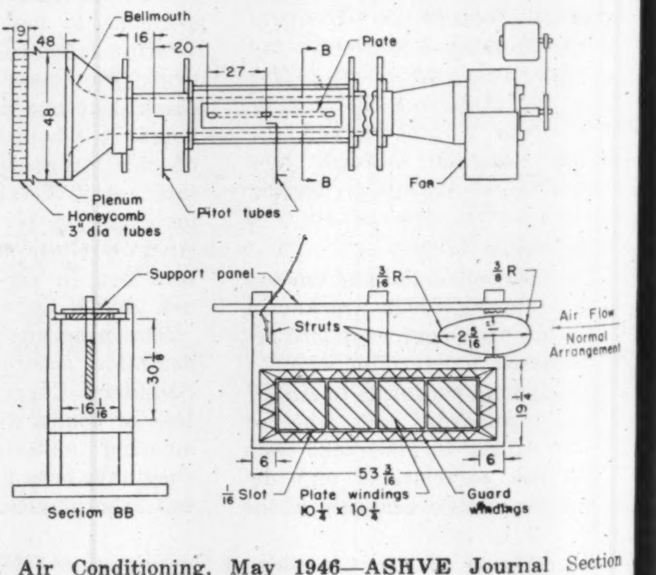


Fig. 1—Details of Wind Tunnel and Heated Plate

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*Research Fellow, ASHVE Research Laboratory. Member of ASHVE.

**Assistant Research Engineer, ASHVE Research Laboratory.

†R. A. Miller, *Chairman;* L. T. Avery, H. C. Dickinson, J. E. Frazier, E. H. Hobbie, Dr. J. C. Hostetter, L. K. Jones, J. H. Lewis, F. L. Martin, W. C. Randall, Vic Sanders, Dean L. E. Seeley, H. B. Vincent, Dr. G. B. Watkins, F. C. Weinert.

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Montreal, Que., Canada, June 1946.

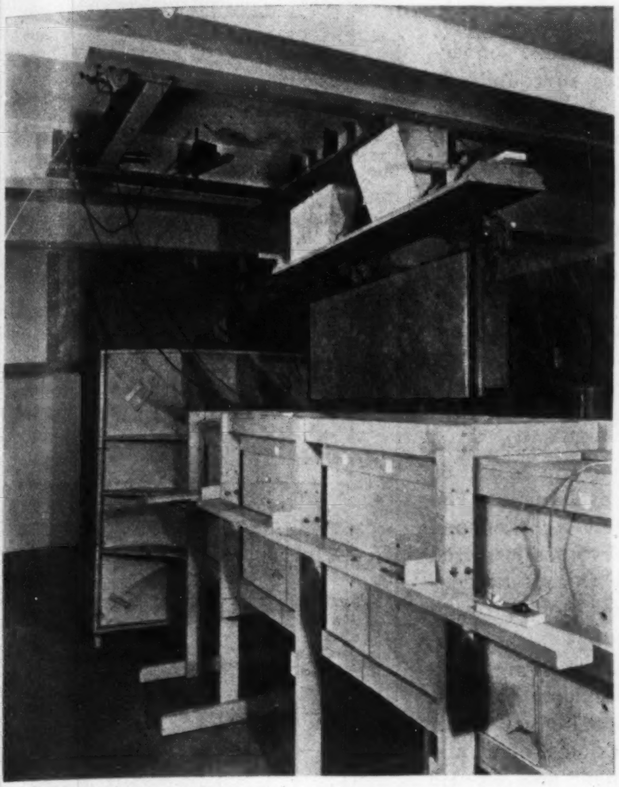

Fig. 2 — Photograph Showing the Plate Assembly with the Cold Junction Ice Boxes, Part of the Wind Tunnel and the Photocell Temperature Control System

1. Normal arrangement (see Fig. 1); leading edge radius of ⅜ in.
2. Reversed arrangement; leading edge radius built up to 15/32 in. to simulate the contour of item 1.

The data listed in this report are, therefore, distinguished according to the characteristic of the leading edge.

Reduction of Data

The unit rate of convection heat transfer from the plate surface was computed as follows: The heat flow was found by subtracting from the electrical input (suitably corrected and converted into heat units) the calculated heat loss by radiation; the temperature difference was based upon the average temperature of the plate and the temperature of the air stream before it passed along the plate surface.

The mechanisms of the diffusion of heat and the exchange of momentum in fluid flow are similar and are related to a common dimensionless number, the Reynolds number, N_R. The relationship between these two processes is expressed by a second dimensionless number, the Prandtl number, N_P. Colburn[1] has shown that the Stanton number N_S, which includes the unit rate of convective heat transfer, can be closely correlated with the friction factor, *f*, if N_P is assigned an exponent of ⅔ and the several terms are grouped as follows:

$$(N_S)\,(N_P)^{2/3} = \tfrac{1}{2}\,f \quad \ldots\ldots\ldots\ldots (1)$$

Goldstein[2] has shown that the skin friction factor for flat plates is closely represented by the expression:

$$f = 0.455/(\log N_R)^{2.58} \quad \ldots\ldots\ldots (2)$$

Therefore, the equation which represents heat transfer becomes:

$$(N_S)\ (N_P)^{2/3} = 0.228/(\log N_R)^{2.58} \quad (3)$$

The right hand member of Equation 3 is seen to equal ½ *f*. The dimensionless numbers are written as follows:

$$N_R = \frac{\rho V L}{\mu};\quad N_S = \frac{h}{c\rho V};\quad N_P = \frac{c\mu}{k}$$

where the fluid properties are:

ρ = Specific weight, lb per cu ft
μ = Viscosity, lb per (ft) (hr)
c = Specific heat, Btu per (lb) (deg F)
k = Specific thermal conductivity, Btu per (hr) (sq ft) (deg F per ft)

and

L = Length of surface, ft
V = Fluid velocity, ft per hr
h = Heat transfer coefficient, Btu per (hr) (sq ft) (deg F)

In reducing the experimental data to dimensionless numbers, the fluid properties were evaluated at the mean of the plate and the air stream temperatures. The length was measured from the leading edge of the heated surface, rather than the nose, and the velocity was measured in the air stream midway between the plate and the tunnel wall about halfway along the plate length (see Fig. 1). The data shown in Fig. 4 are in good agreement with the friction factor (drag coefficient) curve.

In each instance it was necessary to modify the Stanton number by a factor α to take account of the fact that the heat transfer was measured some distance to the rear

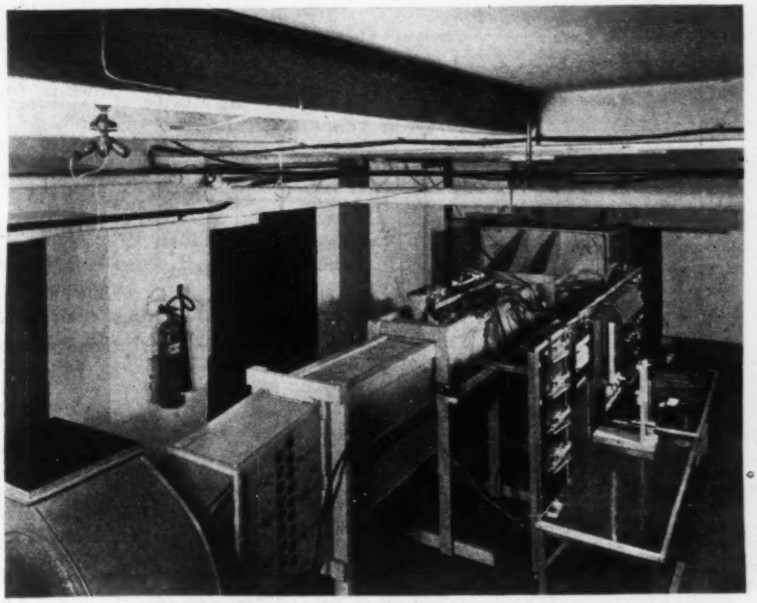

Fig. 3—Photograph Showing the Wind Tunnel with the Plate Installed and the Control Tables

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[1] Exponent numerals refer to Bibliography.

of the leading edge of the heated surface. The validity of the use of this factor, which was derived from the friction formula, is shown by Fig. 5, where experimentally determined mean local heat transfer coefficients (see Table 5) have been brought into close agreement with the friction factor curve. Fig. 6 shows α as a function of the variables Y/L and Reynolds number. The data have been tabulated in Appendix I.

Curves for Engineering Use

Until additional heat transfer data become available, it seems logical to use Equation 3, represented by the solid line of Fig. 4, for the computation of coefficients applicable to conditions beyond the range of the experimental work represented by this report. The curves of Figs. 7 and 8 have been drawn to meet the needs of the air conditioning engineer and are based upon Equation 3. In order to simplify their application it is suggested that the fluid properties be evaluated on the basis of air temperature only. In the usual application the surface-to-air temperature difference rarely exceeds 20 F and, therefore, negligible error is introduced by this simplification. Air properties have been based upon a barometric pressure of 29.92 in. Hg and 50 per cent relative humidity.

Heat exchange by radiation must be computed separately. If conditions permit the assumption that the surface at which forced convection takes place *sees* surroundings at the ambient air temperature, the radiant coefficient can be evaluated and added to the convection coefficient.

Applications

The introduction indicates the rather limited applicability of the data reported here to practical problems in the field of heating and air conditioning, particularly with regard to building surface coefficients. However, the data have general application in the design of some types of heat exchangers. The paper also sheds new light on one of the fundamental values required in the treatment by the *sol-air* concept of periodic heat flow through sunlit walls and roofs.

The importance of the length effect on the film coefficient is best illustrated by computing its effect on overall transmission coefficients. The resistance to heat flow offered by glass is primarily a matter of the resistance of the air films. *For the purposes of illustration only, it will be assumed that the glass installations described in the following conform in all respects to the limitations previously outlined.* Table 1 shows the computed overall coefficient, U, for a parallel 15 mph wind at zero F and for 70 F indoors. The air space width of the multiple sheets has been taken as ½ in. or greater.

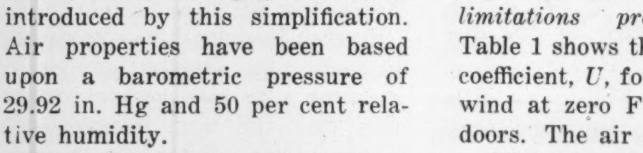

Fig. 4 — Correlation of Heat Transfer Coefficients of a Flat Plate with Skin Friction Factor

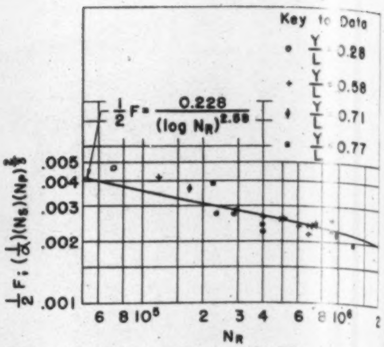

Fig. 5—Comparison of Mean Local Heat Transfer Coefficients Modified by α with the Skin Friction Factor

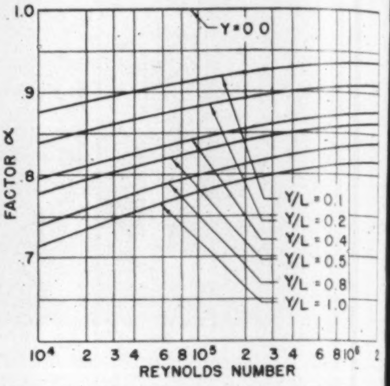

Fig. 6—The Factor α for Turbulent Flow vs Reynolds Number

It should be clearly understood that this table is for purposes of illustration and is *not to be construed as representing practical application coefficients.* The computations show that at 15 mph velocity the indoor coefficient is the controlling factor. For this velocity and when the overall resistance to heat flow is low, such as in single glass, the length effect is pronounced. In the multiple glass the low conductance of the large air space *swamps* the effect of changes in the outside coefficient. Smaller air spaces, of course, have less resistance to heat flow.

It should be recognized that unusual indoor convection currents caused by nearby unit heaters, by radiators, or by air distribution systems will increase greatly the indoor coefficient over the computed values with consequent large changes in U. The effect of unusual radiant heat transfer conditions must also be taken into consideration in practice. Sun effects can be computed separately by methods outlined in a recent research paper[3]. At low air velocities the indoor and outdoor film coefficients become more nearly equal, for example, at 5 mph. The effect of surface length on the overall coefficient is thereby magnified.

A second example of the application of the data given in this report

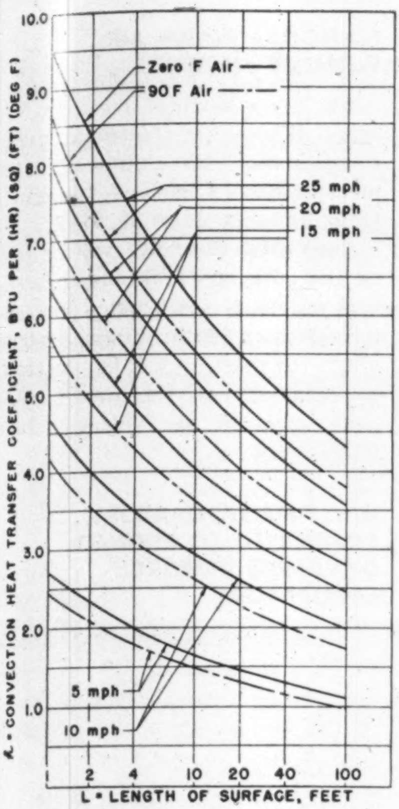

Fig. 7—Convection Heat Transfer Coefficient vs. Length of Surface

can be illustrated in the estimating of heat transfer coefficients for vehicles, such as buses and railroad cars, moving at high speed. Let it be assumed, for example, that a railroad passenger car has 40 ft of glass extending along its side, that its interior temperature is 70 F and that the outdoor temperature is zero. If it is traveling at 70 mph, the weather side convection coefficient, as computed from Equation 3, taking $a = 1.0$, is found to be 10.8 Btu per (hr) (sq ft) (deg F). The U values for single and double windows would be 1.33 and 0.60, respectively. It will be recognized that considerable simplification has been introduced in this example. The film coefficient would be affected by the conditions connected with the actual installation, namely, that the windows do not lie flush with the car surface and that the glass is not a continuous sheet.

It is hoped that a continuation of the study of this general problem will make it possible to evaluate with satisfactory accuracy factors such as the effects of wind direction, general or local roughness of the surface, and large scale eddying or turbulence of the air stream.

Conclusions

1. Coefficients have been determined for the exchange of heat by convection between a smooth flat plate and air passing parallel to it under turbulent flow conditions. For a given air velocity the average unit heat transfer coefficient decreases as the length of the heat transfer surface increases.

2. The combined effects of velocity and length were studied for Reynolds numbers between 0.7×10^5 and 12×10^5. Within these limits a dimensionless number representing the heat exchange was shown to be in close agreement with a dimensionless expression representing the skin friction factor of flat plates.

3. Most satisfactory agreement with this equation was obtained by defining the length parameter as the distance along the plate measured from the leading edge of the heat transfer area. Further investigation is required, however, to fully establish the validity of this treatment.

4. Factors were derived from the skin friction formula whereby the mean local rate of heat transfer at a particular area could be predicted from its location, the flow conditions and the average unit rate of heat transfer of the longer surface of which the area is a part. When the dimensionless heat transfer number, which included an experimentally determined mean local heat transfer coefficient, was modified by the appropriate factor, good agreement with the friction curve was obtained.

5. Curves for use of the air conditioning engineer have been drawn for a considerable range in value of the Reynolds number. These curves show how the convective heat transfer coefficient is affected by surface length and by the air velocity under temperature conditions usually met in heating and air conditioning practice. These are predicated in part upon agreement between skin friction and heat transfer beyond the range of the tests herein reported.

6. These film coefficients have been used in the computation of overall heat transmission coefficients for single sheets of glass and for two and three sheets spaced at ½ in. or more. For the conditions stated in the report the coefficients for a four foot wide glass sheet are greater than the present ASHVE GUIDE values for windows by 4, 24 and 32 per cent respectively (Table 1). For single glass sheets 10 ft wide the average coefficient is equal to the present GUIDE value.

Acknowledgments

The authors gratefully acknowledge the encouragement and suggestions given by various members of the Laboratory staff. In particular they extend thanks to Miss Doris Dietz, Research Assistant, who assisted in carrying out much of the labor of testing and computation, and to William Ryan, who was instrumental in constructing the apparatus.

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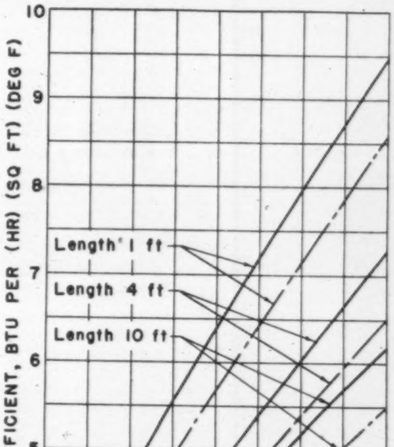

Fig. 8—Convection Heat Transfer Coefficient vs Velocity

Table 1—Calculated Overall Coefficient U, for Smooth Flat Glass—Btu per (hr) (sq ft) (deg F)

Length of Sheet (ft)	2	4	10	20
Single Sheets	1.21	1.18	1.13	1.10
Double Sheets	0.57	0.56	0.55	0.54
Triple Sheets	0.37	0.37	0.37	0.36

Appendix I

Table 2—Summary of Test Results: Plate in Normal Position; Leading Edge Radius ⅜ in.

h	L	V	Temperature F Air	Temperature F Plate	N_R	$(N_S)(N_P)^{2/3}$	Y/L	a	Test No.
2.52	1.19	10.7	76.3	119.8	$0.67\text{x}10^5$	$3.24/10^3$	0.28	0.86	5
3.59	1.19	15.3	76.7	107.6	1.00	3.15	0.28	0.86	4
4.83	1.19	21.6	80.5	103.2	1.43	2.98	0.28	0.87	3
7.82	1.19	40.3	79.8	93.9	2.64	2.62	0.28	0.87	2
9.87	1.19	58.2	81.2	92.4	3.97	2.27	0.28	0.88	1
5.77	2.05	34.8	80.4	100.3	4.09	2.23	0.15	0.91	8
8.83	2.05	58.2	79.2	92.3	6.89	2.03	0.15	0.92	7
2.71	3.76	10.8	80.0	113.0	2.22	3.43	0.09	0.92	12
6.42	3.76	42.9	83.9	97.8	9.06	2.00	0.09	0.93	13
6.44	3.76	43.3	77.7	92.4	9.26	1.97	0.09	0.93	14
6.15	3.76	44.0	80.0	97.8	9.34	2.04	0.09	0.93	10
7.47	3.76	57.9	81.1	95.8	12.45	1.73	0.09	0.94	9

Table 3—Summary of Test Results: Plate Reversed; Leading Edge Radius 15/32 in.

h	L	V	Temperature F Air	Temperature F Plate	N_R	$(N_S)(N_P)^{2/3}$	Y/L	a	Test No.
5.41	1.16	22.2	80.1	88.5	$1.47\text{x}10^5$	$3.24/10^3$	0.28	0.87	40
5.75	1.16	24.9	81.1	88.9	1.65	3.06	0.28	0.87	41
3.89	2.01	18.7	81.0	92.8	1.98	2.74	0.16	0.91	42
4.40	2.01	23.0	82.4	92.8	2.43	2.52	0.16	0.91	43
3.52	2.98	20.3	81.0	93.8	2.96	2.28	0.11	0.93	44a
3.35	3.72	20.3	81.0	94.1	3.76	2.17	0.09	0.93	44b
5.12	1.16	21.9	82.0	101.8	1.40	3.13	0.28	0.87	45
4.00	2.01	21.9	83.2	110.0	2.41	2.45	0.16	0.91	46
7.61	3.72	52.0	83.5	101.7	10.75	1.97	0.09	0.94	47

Table 4—Summary of Test Results: Heat Transfer Coefficients of Heated Surfaces Preceded by Unheated Surface of Length X; Plate in Normal Position; Leading Edge Radius ⅜ in.

h	L	X	V	N_R	$(N_S)(N_P)^{2/3}$	Y/L	a	Test No.
6.94	1.71	2.22	43.8	$4.27\text{x}10^5$	$2.09/10^3$	0.50	0.85	11
4.64	2.57	1.36	30.7	4.47	2.01	0.34	0.88	16
6.34	2.57	1.36	43.1	6.34	1.87	0.34	0.88	15

Table 5—Summary of Test Results: Mean Local Heat Transfer Coefficients of Four Separate Areas of the Plate; Plate in Normal Position; Leading Edge Radius ⅜ in.

h	L	V	N_R	$(N_S)(N_P)^{2/3}$	Y/L	a	Test No.
3.17	1.19	10.8	$0.71\text{x}10^5$	$4.01/10^3$	0.28	0.86	12
8.26	1.19	34.8	2.34	2.42	0.28	0.88	8
7.77	1.19	42.9	2.87	2.42	0.28	0.89	13
8.14	1.19	43.3	2.93	2.49	0.28	0.89	14
7.35	1.19	44.0	3.00	2.43	0.28	0.89	10
8.74	1.19	57.9	3.98	2.01	0.28	0.89	9
9.34	1.19	58.2	3.99	2.15	0.28	0.89	7
2.75	2.05	10.8	1.21	3.48	0.58	0.83	12
5.28	2.05	34.8	4.09	2.23	0.58	0.84	8
6.34	2.05	42.9	4.95	2.20	0.58	0.85	13
6.30	2.05	43.3	5.05	2.21	0.58	0.85	14
6.22	2.05	44.0	6.03	2.25	0.58	0.85	10
7.48	2.05	57.9	6.88	1.87	0.58	0.85	9
8.32	2.05	58.2	6.88	2.03	0.58	0.85	7
2.36	2.91	10.8	1.72	2.93	0.71	0.82	12
5.36	2.91	42.9	6.99	2.02	0.71	0.84	13
5.25	2.91	43.3	7.13	2.02	0.71	0.84	14
5.34	2.91	44.0	7.26	2.08	0.71	0.84	10
6.50	2.91	57.9	9.69	1.80	0.71	0.84	9
2.55	3.76	10.8	2.22	3.23	0.77	0.82	12
6.25	3.76	42.9	9.06	2.12	0.77	0.83	13
6.11	3.76	43.3	9.26	1.87	0.77	0.83	14
5.70	3.76	44.0	9.34	1.89	0.77	0.83	10
6.95	3.76	57.9	12.45	1.61	0.77	0.83	9

Note:

h = convection coefficient, Btu per (hr) (sq ft) (deg F).
L = length in feet measured from leading edge of heated surface.
V = air velocity, *fps*
Y = length in feet measured from leading edge of heated surface to leading edge of test area (L-Y = actual length of test area).
a = a derived ratio of the average heat transfer coefficient (and skin friction factor) of the surface L-Y to that of the surface L.
X = length of unheated surface preceding the heated surface and is equal to 0.17 ft in all cases except as noted in Table 4.

NATIONAL WARM AIR PLAN '47 MEETING

For its midwinter meeting, *National Warm Air Heating and Air Conditioning Association* plans to meet in Hotel Cleveland, Cleveland, Ohio, January 26 to 29, 1947.

Committee meetings will be held on the 26th and 27th and the general program is scheduled for January 28th and 29th. Further details about the meeting will be presented to members at the association's next meeting in Chicago, June 25-26, 1946.

WARTIME LABORATORY CONVERTED TO THERMODYNAMICS RESEARCH LABORATORY

The Central Engineering Laboratory, established by the Government in the Towne Scientific School of the University of Pennsylvania for wartime research and development, has been converted into a Thermodynamics Research Laboratory, with a shift of emphasis toward fundamental research in thermodynamics, it was announced by Dr. George W. McClelland, president of the University.

Under its new name, it will continue to be housed in the Towne School on the Pennsylvania University campus and will be maintained under contract with the Navy Department, Bureau of Ships, as a focal area of fundamental research designed to benefit both governmental and private agencies.

Messrs. Goff, Whitney, Rushton, and McCabe will continue their active association with the new laboratory.

An advisory committee of outstanding scientists and engineers has been appointed to work out long-range planning and direction of the laboratory's program. Serving on this committee are: Earl P. Stevenson, Commodore R. V. Kleinschmidt, Lieut. Comdr. A. T. Scott, Prof. Gerhard Herzberg, Dr. F. D. Rossini, Prof. F. G. Keyes, Prof. Maxwell Gensamer and Dr. H. S. Lukens. The work of the new laboratory will be integrated with the Towne School's regular program of instruction and to that end a number of the school's instructional staff are devoting substantial portions of their time to research in the laboratory as project leaders.

Characteristics of Unit Dust Collectors

By Arthur C. Stern,† Jack Baliff,* Arthur E. Perina,* Robert Crowley,* Benjamin Feiner* and Arthur A. Urbano,* New York, N. Y.

SUMMARY—Test methods and performance standards for unit dust collectors are suggested by the authors and are based upon examination of 28 makes of units and upon performance of 18 collectors. Specifications of the ideal unit dust collector are presented.

During the past four years, 28 makes of unit dust collectors have come to the authors' attention. Their common characteristics are:

1. They combine within the same unit both the means for exhausting the dust laden air and the means for separating the dust therefrom.
2. They are designed for indoor installation immediately adjacent to a dust producing machine.
3. They are small, light and simple enough so that they can be moved and installed by ordinary workmen.
4. They are designed to recirculate the effluent air back into the room in which they are installed.

A wide variety of dust separating means, as shown in Table 1, is employed in the various units, the most common being the replaceable unit filter of the type used in the filter banks of air conditioning and ventilating systems. These filters may be used as either primary or secondary separators. Other units employ cyclones as primary separators and cloth bags or screens as secondary separators. In some units the dust separating means are located on the suction side of the fan; in others on the pressure side; and in still others the fan is located between the primary and secondary separators. A few manufacturers build units of one size only, but the majority build them in two, three or four sizes, a typical series being units rated at 250, 500 and 1000 cfm, respectively.

Specifications for Ideal Unit Collector

In general, a unit collector should meet the following six requirements:

1. It should maintain not less than its rated air flow capacity in cfm throughout the collection of a reasonably large quantity of dust without requiring servicing, such as cleaning of air filters or emptying of hoppers.
2. Its effluent air should at all times have a dust count no higher than that of the atmosphere outside the factory building.[1]
3. Cleaning of the filters or emptying of the hoppers should be simple and should increase neither room dust concentration nor effluent air dust concentration.
4. It should be quiet in operation.
5. It should be of substantial construction so that it will continue to meet the four previously stated requirements throughout normal use and operation.
6. It should not require: (a) Filter rapping or shaking more frequently than once per eight hour day; (b) hopper cleaning or filter brushing more often than once a week; (c) filter removal for replacement, washing or cleaning, more often than once a month.

Standards for Testing Unit Collectors

In order to standardize testing of unit collectors against the foregoing criteria, a dust loading of 1.5 grains of dust per cu ft of air was selected as standard and a test dust was obtained from a foundry tumbling mill exhaust system. The size characteristics of this dust are shown in Table 2 and Fig. 1. It will be noted that on a weight basis the mean size of this dust is 140 μ (microns). A microscopic analysis showed this dust to have a mean size of 3 μ on a particle count basis. It is obviously impossible to select a test dust which will represent all possible dusts that a unit collector may be called upon to collect. Since unit collectors are usually sold from stock by retail machinery dealers, machinery jobbers or sales agents, the manufacturer has little control over the type of dust which each unit may be required to collect. Therefore, units tested and approved against a coarse dust might give rise to a nuisance and a potential hazard when used in collecting a fine dust. However, units tested and approved against a fine dust would also do a good collection job on coarse dust. Therefore, a relatively fine dust should be used in testing unit collectors if the tests are to be used as the basis for approving them for widespread indiscriminate use. The dust selected for these tests has the greater part of its bulk in coarse sizes and will therefore not plug a filter as rapidly as if most of it were fine dust. This allows a fair determination of the length of time required before the need for filter shaking, cleaning or replacement. However, it does have a small percentage of quite fine dust which allows its use in

Table 1—Means of Dust Separation Employed in Commercial Unit Dust Collectors

Means	Number of Units
Centrifugal Separator + Replaceable Air Filter	7
Cloth Screens or Bags (alone)	6
Replaceable Air Filter (alone)	5
Liquid Spray or Impingement (alone)	5
Centrifugal Separator + Cloth Screens or Bags	2
Centrifugal Separator (alone)	2
Centrifugal Separator + Liquid Impingement	1
Total	28

Table 2—Size Distribution of Dust Used for Testing Unit Dust Collectors
(*By Weight*)

Size μ (Microns)	Per Cent of Stated Size[a]	Per cent Less Than Stated Size
420	7.7	92.3
175	33.6	58.7
150	9.9	48.8
75	22.1	26.7
40	19.0	7.7
30	3.7	4.0
20	1.7	2.3
15	0.8	1.5
10	0.4	1.1
7.5	0.35	0.65
5	0.25	0.40
4	0.17	0.33
1	0.18	0.15
<1	0.15	....

[a] Includes particles from stated size up to next stated size.

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[1] See Appendix A.

†Chief Engineer, Division of Industrial Hygiene and Safety Standards, New York State Department of Labor.

*Engineer, New York State Department of Labor.

For presentation at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Montreal, Que., Canada, June 1946.

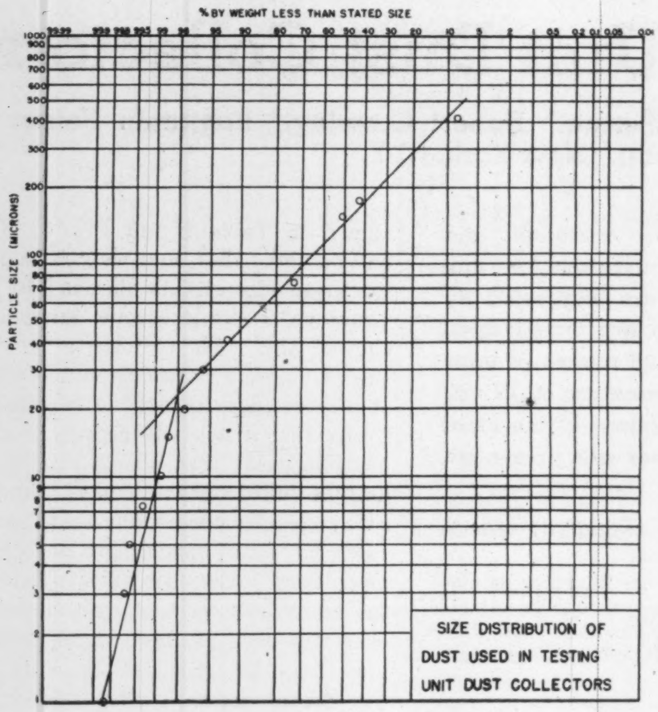

Fig. 1—Size distribution of dust used in testing unit dust collectors

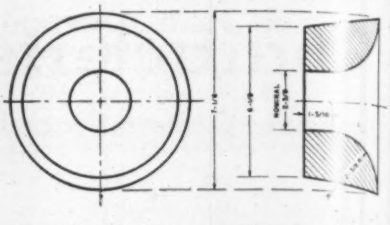

Fig. 2—Design of polished hardwood flow nozzle used in metering plenum

determining the effectiveness of units in collecting fine dust.

It is assumed that a unit will be under dust load 25 per cent of the working time. There is no factual basis for the choice of 25 per cent as the working time factor. It was based upon a knowledge that dust producing operations such as grinding, buffing, sanding, sawing, container filling, etc., are generally of an intermittent character and actually produce dust during only a percentage of the working time. The 25 per cent assumption is higher than will be encountered in many operations but is, in the authors' opinion, reasonable for rating purposes. Under this assumption, the requirement that a unit should not need filter rapping or shaking more often than once per eight hour day is tested by a two hour continuous test at 1.5 grains per cu ft loading. Similarly, under this assumption, the requirement that a unit should not need hopper cleaning more often than once a week means that during a six day week the hopper must have capacity to retain the dust contained in a 12 hour flow at 1.5 grains per cu ft or 1080 grains per cfm of capacity. This is roughly equivalent to 15 lb or ½ cu ft of dust for every 100 cfm of rated capacity. Filters which cannot be either rapped or cleaned should be under the foregoing assumptions, subjected to a 50 hour test at standard loading. However, for reasons which will become obvious later in this paper, no 50 hour tests were necessary.

That 1.5 grains per cu ft is a loading commonly encountered in industry may be easily demonstrated. An 18 in. grinding wheel requires exhaust at about 440 cfm and will grind away from 1/10 to 1 cu in. of steel per minute, depending upon the rate at which the work is fed to the wheel. At this rate of exhaust each 1/10 cu in. of steel removed per minute will produce a dust loading in the exhaust of about 0.5 grains per cu ft. Therefore, the 1.5 grains per cu ft loading used in these tests is equivalent to grinding at the rate of ⅓ cu in. per minute, which is well within the range of ordinary commercial grinding practice.

Test Methods and Equipment

Test equipment has been designed to allow the simultaneous measure-

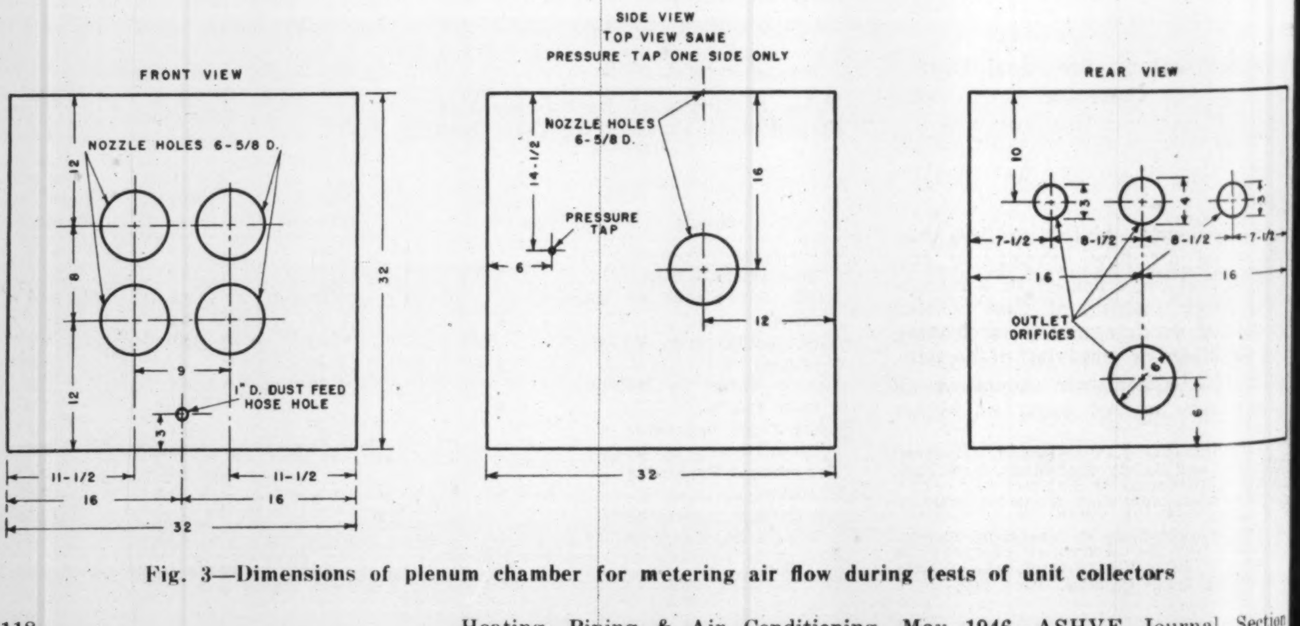

Fig. 3—Dimensions of plenum chamber for metering air flow during tests of unit collectors

ment of: (1) Rate of air flow in cfm; (2) rate of dust feed in grains per minute; (3) dust count of effluent air, mppcf (million particles per cubic foot); (4) inlet static pressure of the unit, inches of water; (5) pressure drop across each dust collecting element in the unit, inches of water.

Rate of air flow was measured by means of rounded approach flow nozzles, Fig. 2. Seven such nozzles, made of hard wood, turned to accurate profile, shellacked and polished, were inserted in the front, top and side walls of a large plenum chamber, Figs. 3 and 4. This plenum chamber is made of shellacked plywood glued to a heavy wooden frame to prevent leakage at the joints. The joint between the tapered exterior of each flow nozzle and its hole in the wall of the plenum was sealed with a plastic sealing compound. The number of flow nozzles in use at any one time is controlled by inserting rubber stoppers into the orifices of nozzles which are to be closed. By this means, it was possible to vary, from one to seven, the number of nozzles through which air flows to the plenum. Test practice has been to close side wall, rather than front wall nozzles, whenever three or fewer nozzles are to be closed.

Although these nozzles are nominally of $2\frac{3}{8}$ in. throat diameter, each has been carefully calipered several times and the actual, rather than nominal, diameter used in calculating air flow. The pressure in the plenum was measured by a 2 in. inclined tube draft gage. No temperature or barometer corrections were made, insofar as all flow computations were made using the formula:

$$Q = CA\ 4005\ \sqrt{h}$$

Q = cfm at 68 F—30 inches mercury

C = nozzle coefficient—taken as 0.98

A = area of open nozzles in sq ft

h = plenum pressure—inches water

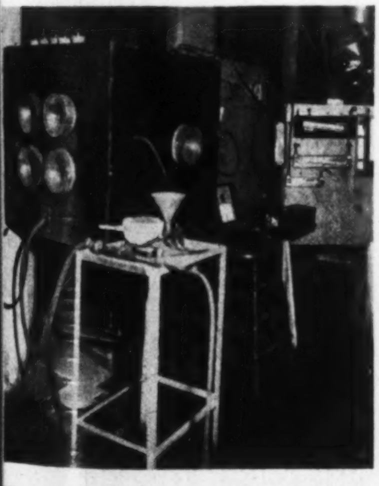

Fig. 4—Photo of plenum chamber for metering air flow

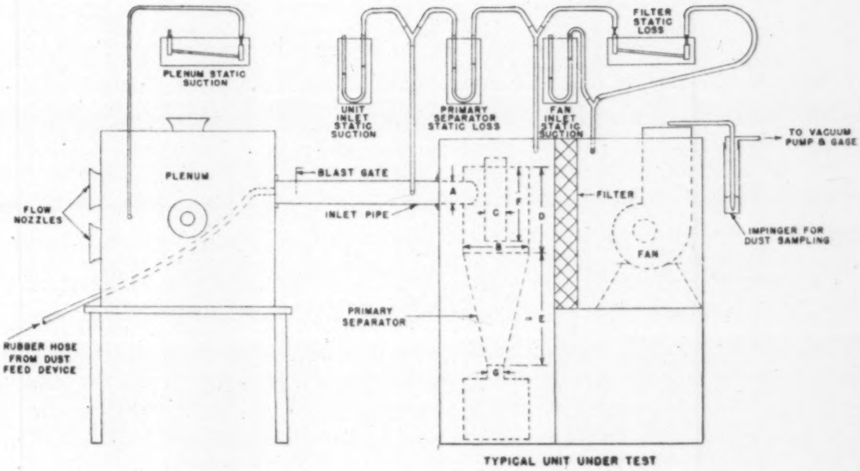
PLENUM STATIC SUCTION
UNIT INLET STATIC SUCTION
PRIMARY SEPARATOR STATIC LOSS
FAN INLET STATIC SUCTION
FILTER STATIC LOSS
TO VACUUM PUMP & GAGE
PLENUM
FLOW NOZZLES
BLAST GATE
INLET PIPE
A
B
C
D
E
F
G
FILTER
FAN
IMPINGER FOR DUST SAMPLING
PRIMARY SEPARATOR
RUBBER HOSE FROM DUST FEED DEVICE
TYPICAL UNIT UNDER TEST

Fig. 5—Set up for testing unit dust collectors

One wall of the plenum chamber is equipped with outlet holes of several diameters[2] so as to allow connection to different sized unit inlet pipes. Those not in use are sealed. Those in use are connected by a flanged coupling to a blast gate, which in turn is connected by a length of straight duct to the inlet of the unit collector, Fig. 5, under test. The length used, in most cases, was about five feet in order that the blast gate might not adversely influence the measurement of unit inlet static pressure. This latter measurement generally has been made by placing a pressure tap in the straight length of duct near its junction with the collector. In a few cases, where an inlet plenum was a part of the collector design, the inlet static pressure tap was taken from this plenum. Inlet static pressure was measured by a *U* tube water gage.

Location of pressure taps to measure pressure drop across the various dust collecting elements varied according to unit construction. Centrifugal separator pressure drops were measured by a *U* tube water gage. Air filter, cloth screen and cloth bag pressure drops were measured by an inclined tube draft gage as long as the pressure drop remained within gage limits; beyond that a *U* tube water gage was used.

Dust Feeding Procedure

Dust feed to the unit under test was by means of a No. 2 Hancock ejector (Fig. 6) operated by compressed air at 8-10 psi. A member of the test crew manually fed dust into a funnel connected to the suction inlet of the ejector at a con-

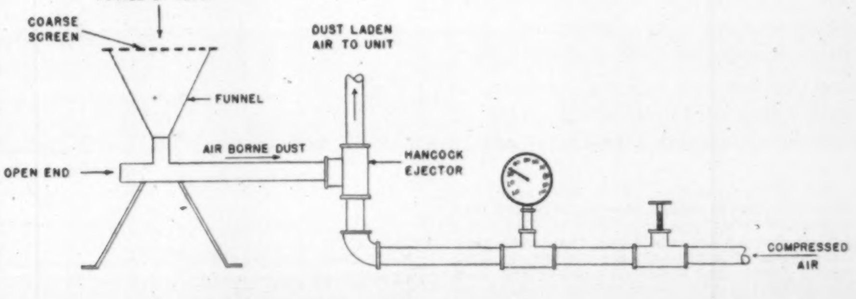
DUST FED TO FUNNEL BY SCOOP
COARSE SCREEN
FUNNEL
DUST LADEN AIR TO UNIT
AIR BORNE DUST
OPEN END
HANCOCK EJECTOR
COMPRESSED AIR

Fig. 6—Method of feeding dust to unit under test

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[2] In future designs, it is recommended that low loss rounded approach nozzles be used as outlets rather than the sharp edged orifices used in the author's tests. This will allow lower metering loss than was possible with the plenum design.

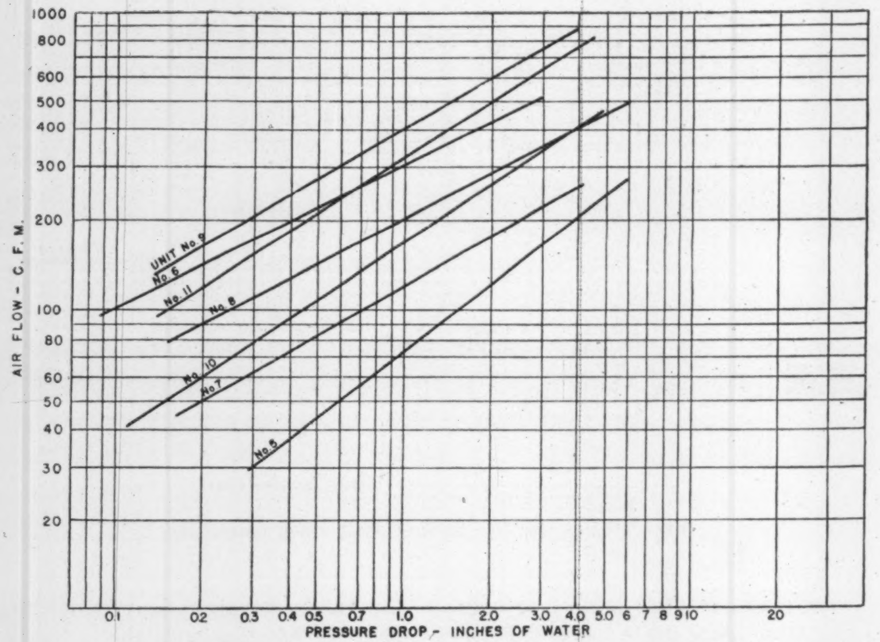

Fig. 7—Air flow vs. cyclone pressure drop for various units

stant measured rate using various sizes of scoops, the level capacity of which had been previously determined. Feed rates were varied by varying the scoop size and maintaining wherever possible the rate of four scoops per minute. Experience shows that this procedure maintains a uniform (and easily varied) rate of feed and is preferable to automatic feed where time required for feeding is not too great. It is necessary to prevent ejector nozzle from clogging in order to maintain dust feed. This requires exclusion from the feed of extraneous matter such as splinters, paper, scale, etc., and this is easily accomplished by placing a coarse mesh screen over the funnel into which dust is fed.

The discharge from the ejector carrying the test dust in suspension was piped through rubber tubing through the front wall of the plenum chamber and terminated in front of the center of the opening to the duct from the plenum to the unit under test.[3] In this manner the suspended test dust was blown into the duct leading to the unit being tested. In order to avoid the complication of having to measure the air used to transport dust, the test procedure was to shut off the air flow through the aforementioned rubber tubing whenever it was desired to measure air flow into the unit under test. Because of this procedure, dusting tests actually consisted of a series of runs with the compressed air injection in operation while dusting and turned off while metering. The unit, of course, ran continuously during the test regardless of whether or not compressed air feed was operating. Since all test results reported herein are based upon data obtained during metering runs with compressed air turned off, they are the same as would have been obtained by any other method of supplying dust. The quantity of compressed air supplied each unit while dusting was negligible in comparison with the quantity of air handled by the unit in ordinary operation and had no adverse effect upon the results of these tests.

Test Procedure

Test procedure was generally to measure all static pressures and air flow through the unit first with the blast gate wide open and then with it closed by successive steps from fully open to fully closed. Several *clean air* check runs of the unit were made and plotted before *dusting* any of the units tested. Following this, all units containing filters or cloth surfaces designed for rapping or shaking, rather than replacement, were subjected to several unmetered *dirtying* runs, each followed by a rapping or shaking of the filters or bags, in order to change the filtering element from the clean to the *shaken* condition. After bringing the unit to the *shaken* condition, the final series of *dusting* runs were undertaken. As has already been noted, a dusting run consisted of alternately dusting and measuring air flow and pressures. As a rule units were dusted ten minutes after which the compressed air was turned off; the taking of pressure readings generally required from one to five minutes of time, depending upon whether readings were taken only with blast gate fully open, or with various degrees of throttling. Following the taking of pressure readings, the compressed air was turned on again and dusting resumed for another cycle. These cycles were

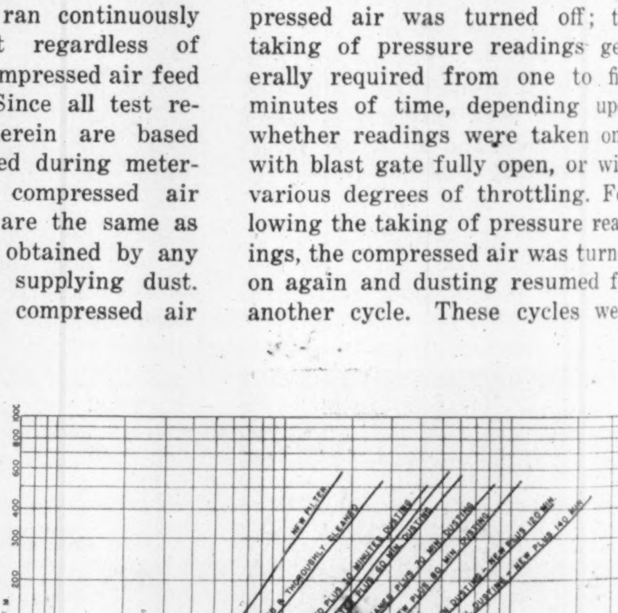

Fig. 8 — Typical family of curves of filter pressure drop vs. air flow for unit No. 10

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[3] In future designs, it is recommended that the ejector discharge be injected into the duct from the plenum to the unit under test at a point after the blast gate by means of a branch connection to that duct. This will lower the metering loss by removing the obstruction created by the presence of the dust tube in front of the plenum outlet inside the plenum chamber.

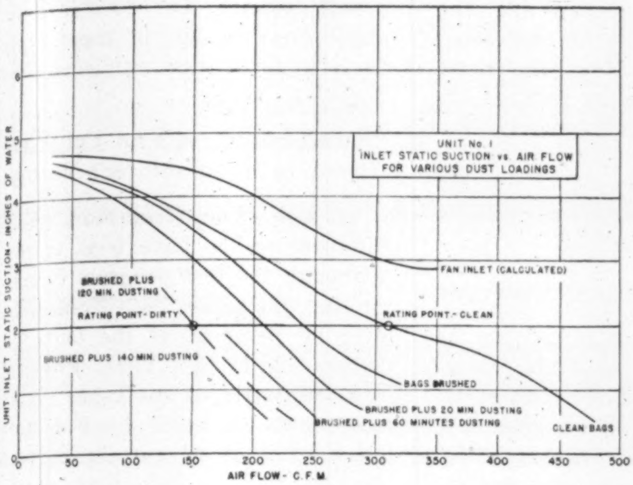

Fig. 9—Inlet static suction vs. air flow for various dust loadings for unit No. 1

continued for two hours at a dust feed rate of 1.5 grains per cu ft[4] unless an earlier test end point was indicated. This was desirable when (*a*) the collector hopper became filled before the end of the two hour period; (in the case of centrifugal collector hoppers, the hopper was considered filled when the level rose to the height at which reentrainment of dust from the hopper occurred); or (*b*) when dust visibly escaped from the unit outlet (in some units tested, dust escaped visibly from the very start of the test, and runs were, therefore, stopped as soon as it became evident that further operation would not improve the situation).

When counts were made, the effluent air was sampled by means of a Greenburg-Smith impinger, at the rate of 1 cfm for 10 min. Counts were made by the standard low power-light field technique. Counts were not taken when there was visible effluent dust from a unit since this alone was taken as indicating excessive dust count of the effluent air. In several collectors where this occurred, the effluent dust came largely from around filters rather than through them. However, since collectors were being tested in the *as manufactured* condition, very little effort was made to improve the fit of filters or make other changes in the unit. The only modifications made in the collectors tested consisted of (*a*) adjusting a fan rotor if it rubbed the casing when received, (*b*) stiffening the casing back of a fan rotor to prevent its collapse inward against the rotor when the unit was placed under a static no delivery test, and (*c*) adding a gasket to a filter frame of a unit to allow its test to be run to completion.

Plotting Test Data

The test data from each test run were routinely plotted as follows:

1. Pressure drop across centrifugal collector in inches water against air flow in cfm, Fig. 7.
2. Pressure drop across filter or cloth in inches water against air flow in cfm, Fig. 8.
3. Inlet static pressure in inches water against air flow in cfm, Fig. 9.

In all instances, the pressure drop *vs.* air flow plots yielded straight lines on double logarithmic coordinates. In the case of centrifugal collectors, one such line represents both clean and dirty operation, Fig. 7, whereas for filter or cloth there is a different straight line for each state of dirtyness, Fig. 8, *i.e.*, the line shifts as the unit collects dust. Use was made of these graphs to determine the maximum air flow obtainable with a unit collector disconnected from the metering plenum, inlet duct and all other external resistance to air flow. When the unit was operated in this condition, the pressure drop across its centrifugal collector or filter elements was measured and the air flow corresponding to that drop obtained by extrapolation of the *pressure drop-air flow line* previously plotted for the unit.

Determination of Inlet Static Pressure

In the test set up described, the pressure drop ahead of the inlet static pressure tap consisted of four parts: (1) the drop through the metering flow nozzles; (2) the drop at the inlet of the duct from the plenum to the unit; (3) the friction loss in that duct; and (4) the throttling loss past the blast gate in that duct. This latter drop disappears when the blast gate is full open, as is the case when measuring maximum metered flow. The minimum drop across the metering flow nozzles occurs when all seven nozzles are open and in use. Duct drop and drop from plenum to duct may both be estimated. Table 3 shows for each size of inlet duct the cfm required at 4000 fpm; the pressure drops in metering this cfm using all seven orifices; in passing it through straight duct to the unit with blast gate open; and in entrance to this straight duct. The table also shows the sum of these three pressure drops plus 1 in. velocity head, equivalent to 4000 fpm. This sum, therefore, represents the theoretical minimum inlet static pressure measurable by our test setup at 4000 fpm unit inlet velocity. This analysis has been based on 4000 fpm velocity because the New York State Dust

Table 3—Computation of Theoretical Minimum Inlet Static Pressure Obtainable at 4000 fpm Inlet Velocity Using Test Setup Employed in These Tests

Duct Diameter Inches	CFM at 4000 FPM	Plenum Drop With All 7 Nozzles In. H_2O	Duct Drop In. H_2O	Drop on Inlet to Duct In. H_2O	Theoretical Minimum Inlet Static Pressure[a] In. H_2O
3	196	0.059	0.42	0.47	1.95
3½	267	0.110	0.33	0.47	1.91
4	349	0.187	0.28	0.47	1.94
4½	440	0.298	0.24	0.47	2.01
5	544	0.455	0.21	0.47	2.14
5½	660	0.670	0.18	0.47	2.32
6	786	0.950	0.16	0.47	2.58

[a] Includes 1 inch velocity pressure.

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[4] Accelerated loading was used for the last half of some tests by feeding dust at rates two and four times 1.5 grains per cu ft for a half or quarter hour respectively so that the total weight of dust fed remained the same as if the 1.5 grain rate had been maintained for the hour.

Collecting Code (Code Bulletin No. 12) requires a minimum of 2 in. static suction in the branches of dust collecting systems. This presumes a branch velocity of 4000 fpm and a hood of average construction having an entrance loss equal to one velocity head in the branch.

It will be noted from Table 3 that the test setup, therefore, theoretically allows units to be tested at very close to the code requirement of 2 in. static suction and, by throttling, allows testing at all higher inlet static pressures up to the static no delivery point of the unit. In actual test setups of units having the various sized inlet ducts in Table 3, maximum (unthrottled) inlet duct velocities both higher and lower than 4000 fpm were found. In most cases where the velocity was lower than 4000 fpm, the minimum measurable inlet static suction was lower than that shown in Table 3. Conversely, where the maximum velocity exceeded 4000 fpm or where pressure losses additional to those considered in Table 3 were met (as, for instance, where elbows had to be used to connect the plenum to the unit under test), the minimum measurable inlet static suction was higher than that shown in the table. Whenever the minimum measurable inlet static suction was in excess of 2 in., it was necessary to determine the air flow at 2 in. inlet static pressure graphically, by extrapolating the inlet static pressure-cfm curve of the unit in question until it crossed the 2 in. pressure line. The corresponding value of cfm could then be obtained from the curve and used as the rating point of the unit, see Fig. 9. Fortunately, this procedure was required in only a few cases because most of the test runs included a reading at or below 2 in. inlet static suction.

Basis for Rating Unit Collectors

Rated cfm of a unit collector as based upon these tests is, therefore, the flow at 2 in. inlet static after the unit has accumulated dust for two hours as previously noted. This flow may be one that was actually measured, or one extrapolated to 2 in. inlet static in those cases where the test data did not drop that low in inlet static. The cfm rating could not be established on this basis for any unit in which the hopper became filled or from which dust visibly escaped before the end of the 2 hour dusting test. However, units in which this occurred were not acceptable, *per se*, and a cfm rating would, therefore, be meaningless and misleading if given. It should be noted that free inlet air flow has no useful significance, since it can never be realized in practice. It should also be obvious that the free inlet flow decreases as the filter or cloth elements become more dirty. Despite these facts, the practice has arisen of rating commercial unit collectors on their free inlet flow in the clean condition. One of the principal objectives of the tests herein reported was to determine how far the usable capacity (*i.e.*, the 2 in. inlet static dirty rating) of these units deviated from their published free flow clean rating.

Characteristics of Unit Collectors Based on Manufacturer's Rating

To date 18 unit collectors of 13 different makes have been tested. Although the test program is continuing, the makes tested represent over 90 per cent of the unit collectors sold in New York. Physical characteristics of the types tested are shown in Table 4. For purposes of analysis certain derived data as given in Table 5 are easier to interpret than the data of Table 4.

Motor Horsepower Per 1000 Cfm

From Table 5 it will be seen that among the units tested, motor hp per 1000 cfm manufacturer's rated capacity varied from 0.35 to 3.3.

A unit rated at 2 in. inlet static pressure will require at least an additional 2 in. static pressure to drive the air through its dust collection device when the latter is in the dirty condition. It is, therefore, apparent that the fan static pressure must in almost all cases be at least 4 in. At 4 in. static pressure the required hp per 1000 cfm is equal to or greater than 1.3. Despite this fact, it will be seen that 6 of the 18 units tested had motor hp per 1000 cfm of under 1.3 and are obviously underpowered for the manufacturer's claimed rating even without testing the unit to prove the fact.

Table 4—Physical Characteristics of Unit Collectors Tested

Unit No.	Mfr's. Rated Capacity CFM	Filter Area Sq Ft	Hopper Capacity Cu Ft	Motor HP	Fan RPM	Fan Type[a]	Inlets (as tested) In.	Filter Media
1	500	60	0.44	½	3450	F C	2-3	Cloth bags (steel wool filled)
2	500	60	0.44	½	3450	F C	2-3	Cloth bags (steel wool filled)
3	600	120	0.45	1	3450	F C	1-6	Cloth bags (steel wool filled)
4	1000	45	3.0	1½	3450	F C	2-3	Cloth bags
5	325	4	0.18	¼	3400	F C	1-3	Hair glass mat
6	450	120	2.3	1	3450	F C	1-4	Cloth bags (steel wool filled)
7	500	3½	0.55	¾	3450	F C	2-3	Paper pad filter
8	550	11	1.0	¾	3600	F C	1-4	Cloth screen
9	880	16½	3.8	2	3450	P W	1-6	Steel wool filter
10	950	7¼	0.23	⅓	3450	F C	1-5	Glass wool filter
11	1250	13	0.23	1½	3450	F C	1-6	Glass wool filter
12	270	28.5	2.75	½	3450	[b]	1-3½	Wool felt screen
13	450	2.5	2.3	1½	4300	[b]	1-4	Metal oiled filter
14	400	0	0.27	⅓	3450	F C	1-2½	None
15	700	0	[d]	1	3475	P W	[c]	None
16	1000	0	[d]	2	2200	P W	1-8	None
17	350	60	1.37	½	3450	P W	1-4	Cloth bags
18	985	94	1.13	2	3450	P W	1-6	Cloth bags

[a] F C—Forward Curve; P W—Paddle Wheel.
[b] Dynamic Precipitator type combined fan and dust separator. Fan is of P W type.
[c] Directly connected to grinding wheel hood.
[d] Sludge tank.

Table 5—Derived Data on Unit Collectors Tested Based on Manufacturer's Rated Capacity

Unit No.	Motor HP/1000 CFM	Filter Velocity ft/min	Hopper Capacity per 100 CFM (cu ft)	Inlet Duct Velocity ft/min
1	1	8.3[a]	0.09	5080
2	1	8.3[a]	0.09	5080
3	1.67	5.0[a]	0.08	3060
4	1.5	22	0.30	10200
5	0.77	81	0.06	6600
6	2.22	3.8[a]	0.51	5160
7	1.5	143	0.11	5080
8	1.36	50	0.18	6300
9	2.28	53	0.43	4480
10	0.35	131	0.03	6950
11	1.2	96	0.02	6360
12	1.85	9.5	1.0	4050
13	3.33	180	0.51	5150
14	0.833	.....	0.07	11700
15	1.43	.....	....	....
16	2.00	.....	....	2860
17	1.43	5.8	0.39	4000
18	2.04	10.5	0.11	5000

[a] Actual velocity approximately 3 times higher because only ⅓ of filter area is effective area.

Filter Velocity

Similarly it will be seen that filter velocities based on manufacturer's rated capacity range from 3.8 to 180 fpm. In the case of those units having filter velocities of 3.8, 5.0 and 8.3, respectively, the velocity is based upon the gross cloth area of the unit. However, by observing the bags of these units after extensive accumulation of dust, it was seen that only about one-third of the cloth area became dirty, the remaining cloth surface being in such close contact with adjacent cloth surface that it was not actually available as filter surface. The actual velocities in these units are therefore about three times that shown in Table 5 and are about 11.4, 15.0 and 25.0 fpm, respectively. Conventional commercial cloth screen and bag dust arresters for permanent installation are designed to operate at from 2 to 4 fpm filter velocity. Even though, in the interest of compactness, somewhat higher velocities may be desirable, it is doubtful if good practice can tolerate such higher velocities except in those cases where either a precleaner of exceptionally high efficiency is used ahead of the filter, or the filter surface is frequently cleaned automatically.

Hopper Capacity Per 100 Cfm

Table 5 also shows that hopper capacity per 100 cfm manufacturer's rated capacity varied from 0.02 to 1.0 cu ft. In three units hopper capacity per 100 cfm was over 0.50 and therefore conform to the standard previously noted. The three units with capacity per 100 cfm of 0.30, 0.39 and 0.43 cu ft are not excessively low. The other ten seem to have much less than the desired hopper capacity. It was noted that in all but one of the cloth bag and screen type units, the dust hopper was located in such a position that the incoming air swept across the hopper at relatively high velocity. This tended to prevent utilization of the full hopper capacity by re-entraining some of the finer dust from the hopper after a critical level had been reached.

Characteristics of Cyclone Separators Tested

Seven of the units tested employed a cyclone separator as the primary means of dust collection. The dimensions of these cyclones listed in Table 6 are those shown on the typical cyclone in Fig. 5. The pressure drop versus cfm characteristic of each of these cyclones is shown graphically in Fig. 7. The numbers used to identify the lines on Fig. 7 are the unit numbers listed in the left hand column of Table 6. No correlation has yet been attempted between cyclone dimensions and cyclone pressure drops. However, it is hoped that as more data of this type accumulates as a result of these tests, such correlation may become possible.

Dust Counts in Effluent Air from Collectors

It was known before these tests were run and confirmed by them that when dust collector effluents are visibly dusty, the effluent air dust count is in excess of 100 mppcf.[5] Thus the effluent of unit 15 which was visibly dusty when the water level was set too low had an effluent dust count of 324 mppcf (Table 7). It was therefore deemed unnecessary to make confirmatory dust counts when collector effluents were visibly dusty. This condition was observed in units 5, 7, 9, 13 and 14 as well as in unit 15 when the water level was too low.

Units 2, 3, and 6 had filter media identical with unit 1 and their effluents were therefore not sampled. The effluent of unit 4 was visibly clean but no counts were made. As originally tested, unit 12 leaked dust around the filter. However, to determine the efficiency of the filter media, the leaks around the filter were stopped by gasketing and the dust count was then obtained and recorded.

No consistent trend of counts with continuing dusting was observed which is applicable to all units. Units 1 and 8 are of the cloth type. In the former, counts were higher after the bag had a dust layer than before. This is probably due to increased leakage around the filters at high pressure differentials across them. Units 10 and 11 are of the glass wool filter type. In two test runs on unit 10 and one on unit 11, dust counts decreased as the filter became loaded. In one run on unit 11, a reverse trend was noted which may be accounted for by the fact that this occurred toward the end of a run of long duration. It is possible that

Table 6—Dimensions of Cyclone Separators in Unit Collectors Tested (Inches)

Unit No.	Number of Cyclones	Cyclone Inlet[c] A	Cyclone Diameter B	Inner Cylinder Diameter C	Height of Outer Cylinder D	Length of Cone E	Length of Inner Cylinder F	Dust Outlet Diameter G
5	1	3	11¾	4½	5½	17½	10½	2
6	1	7½x2¾	12	6	16	22¼	14	5⅝
7[a]	2	3	8	4½	5¼	11⅝	?	4
8[b]	1	4	16	9	14	0	9¾	0
9	1	6	19	10	7½	26	12	6
10	1	6x3	9	5⅛	11¾	17¾	8	2½
11	1	8x4¼	13¼	7 7/16	18	18	12	4

[a] Two cyclones of same dimensions in parallel.
[b] Cyclone has no bottom cone.
[c] Dimensions as shown on Fig. 5.

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[5] Mppcf = million particles per cubic foot.

Table 7—Unit Outlet Dust Counts[a]

Unit No.	Count mppcf	Feed rate grains/cu ft	Unit previously dusted at 1.5 gr/cu ft rate (equiv) min	Notes
1	29.8	0.375	0	Bags rapped
1	29.8	0.75	5	Dusting started after bags rapped
1	67.2	1.5	10	Dusting continued
1	146	3.0	140	Bags loaded with dust
8	39.4	1.5	20	Filter cloth as received (previously dirtied)
8	97.5	1.5	20	Filtercloth after brushing
10	91.2	1.5	10	Filter clean at start
10	57.6	1.5	50	Dusting continued
10	37.4	1.5	80	Dusting continued
10	24.6	1.5	110	Dusting continued
10	19.2	1,5	130	Dusting continued
10	29.4	1.5	10	Filter rapped at start
10	10.4	1.5	50	Dusting continued
10	24.0	1.5	100	Dusting continued
10	13.2	1.5	110	Dusting continued
11	18.8	1.5	220	Filter clean at start—dusted
11	34.6	1.5	350	Dusting continued
11	30.0	3.0	40	Filter rapped at start—dusted
11	17.4	3.0	280	Dusting continued
12	5.0	3.0	100	Additional gasketing placed around filter frame to suppress leaks
15	324	1.5	0	Water level too low—detergent added to water
15	16.0	1.5	0	Water level correct — detergent added to water
15	15.0	1.5	0	Water level correct — detergent added to water
16	24.0	1.5	0	Operating at 57 per cent rated capacity plain water
16	32.0	1.5	0	Operating at 57 per cent rated capacity plain water
16	35.0	1.5	0	Detergent added to water
17	5.6	1.5	10	Bags shaken at start
17	3.8	1.5	40	Dusting continued
17	3.6	1.5	120	Dusting continued
18	3.8	1.5	0	Bags shaken at start
18	1.2	1.5	60	Dusting continued
18	3.0	1.5	120	Dusting continued

[a]Units 5, 7, 9, 13 and 14 had excessive dust in effluent by visual observation. Units 2, 3 and 6 use same filter media as unit 1: No visible dust from unit 4.

Table 8—Characteristics of Unit Collectors Tested Based on cfm at 2 in. unit inlet static pressure with unit clean

Unit No.	CFM	Per Cent of Mfr's Rated Capacity	Inlet Duct Velocity ft/min	Hopper Capacity cu ft per 100 cfm	Filter Velocity ft/min	Motor HP per 1000 cfm
1	315	63	3200	0.14	5.2[c]	1.59
2	580	116	5900	0.08	9.7[c]	.86
3	850	141	4320	0.05	7.1[c]	1.18
4[a]	700	70	7120	0.43	15.5	2.14
5	140	43	2850	0.13	35.0	1.78
6	430	95	4960	0.54	36.0[c]	2.32
7	415	83	4220	0.13	120.0	1.80
8	315	57	3600	0.32	38.6	2.38
9[a]	1000	113	5100	0.38	60.6	2.00
10	225	24	1650	0.10	31.0	1.48
11	620	50	3160	0.04	47.6	2.42
12	305	113	4560	0.90	10.7	1.64
13	420	94	4820	0.55	168.0	3.57
14[b]	160	40	4700	0.17	.....	2.08
15[b]	(d)	...	....	....	.....	....
16[b]	400	40	1150	....	.....	5.00
17	400	114	4600	0.34	6.7	1.25
18[a]	1800	180	9000	0.06	19.2	1.11

[a]Approx.—Flow measurement beyond range of test set up at 2 in static pressure.

[b]Clean and dirty rating the same because unit contains no filter to increase in resistance.

[c]Actual velocity is approximately 3 times higher because only about ⅓ of filter area is effective area.

[d]Air flow varies with water level: At high level flow is low and dust collection high; at low level, vice versa.

the dust holding capacity of the filter had been exceeded so that continued dusting allowed greater escape of dust, whereas up to this point the reverse was true. In the case of unit 15, it was observed that when the water level was lowered, the visible dust concentration of the effluent increased, and vice versa.

It is noteworthy that only 3 units had dust counts below 5 mppcf. Since one would expect ambient room counts, without recirculation from a dust collector, to be well under 3 mppcf in any room in which a unit collector is installed, it appears that only one of the units tested meets the suggested standard[6] of a maximum dust concentration in the unit effluent of 3 mppcf in excess of ambient dust count.

Test Results—Clean Rating

The clean ratings (cfm at 2 in. unit inlet static suction before dirtying filter) of the 18 units tested are shown in Table 8, together with some data derived therefrom. On this rating basis, only units 2, 3, 9, 12, 17 and 18 have a capacity equal to or in excess of rated capacity; units 1, 5, 10, 11 and 16 have too low an inlet velocity, and units 2, 3 and 18 too low a motor hp per 1000 cfm. Filter velocities are uniformly too high and, with the exception of units 6, 12 and 13, hopper capacity uniformly too low.

Test Results—Dirty Rating

The dirty ratings (cfm at 2 in. unit inlet static suction after dirtying filter) of the 18 units tested are shown in Table 9 together with some data derived therefrom. In the authors' opinion the ratings shown in this table are those upon which use in the field should be based. Because these ratings are in all instances lower than manufacturer's rated capacity and since inlet duct velocity in over half the units is below acceptable limits, it is obvious that these units are as a class not only overrated but also are provided with excessively large inlet duct area. Included in Table 9, therefore, is a column headed *Proper Inlet Diameter Inches*, which shows the inlet diameter necessary to maintain at least 4000 fpm inlet velocity at the dirty rating listed. These are the inlet diameters which, in the authors' opinion, should be provided on these units rather than those actually provided. In five of these units indicated by note g in Table 9, the proper inlet diameter is either 2 or 2½ in. However, none of the New York State dust control codes lists operations where branches smaller than three inches may be employed. *These* particular units are, *therefore*, undersize for all dust control operations.

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[6]See Appendix A.

Table 9 also includes a column headed *Effluent Dustiness* and a footnote showing the rating scale for dustiness. This rating is difficult to correlate with the dust counts of Table 7 since it is qualitative rather than quantitative. With regard to the three wet units without filters which were tested, the rating *C* given means that visible dust blew through the unit.

By way of summary, a bar chart, Fig. 10, has been prepared showing how each unit tested compares with the various arbitrary standards suggested. The preferable units are those which most nearly meet or exceed the most of these standards.

Some performance factors, such as ease and cleanliness of cleaning filters and emptying hoppers, the rigidity of construction and the noisiness of operation had to be determined objectively. If the importance of quietness of operation had been realized early in these tests, noise level on each unit tested could have been measured. Unfortunately, this realization came slowly as more and more noisy units were tested. Specifications for unit collectors should include a limiting noise level.

Table 9—Characteristics of Unit Collectors Tested

Based on cfm at 2 in. unit inlet static pressure with unit dirtied for equivalent of 2 hours at 1.5 grains per cu ft loading of dust having mean size of 140 microns on weight basis and of 3 microns on particle count basis.

Unit No.	CFM	Per Cent of Mfr's Rated Capacity	Inlet Duct Velocity ft/min	Hopper Capacity cu ft per 100 cfm	Filter Velocity ft/min	Motor HP per 1000 cfm	Effluent Dustiness[h]	Proper Inlet Diam. Inches
1	150	30	1530	0.29	2.5[d]	3.34	B	1-2½[g]
2	240	48	2440	0.18	4.0[d]	2.08	A	1-3
3	565	94	2880	0.08	4.7[d]	1.77	A	1-5
4[a]	600	60	6100	0.50	13.3	2.50	A	2-3½
5	b	b	b	b	b	b	D	1-2[g]
6[f]	430	95	4960	0.54	3.6[d]	2.32	A	1-4½
7	b	b	b	b	b	b	C	1-4
8	200	36	2300	0.50	18.2	3.75	C	1-3
9	b	b	b	b	b	b	D	1-6
10	125	13	915	0.18	17.2	2.66	C	1-2[g]
11	505	40	2570	0.05	38.8	2.97	C	1-4½
12	175	65	2620	1.57	6.15	2.86	B	1-2½[g]
13	b	b	b	b	b	b	D	1-4
14[c]	160	40	4700	0.17	....	2.08	C	1-2½[g]
15[c]	e	..	....	....	....	....	e	.....
16[c]	400	40	1150	....	....	5.00	C	1-4
17	240	69	2760	0.57	4.0	2.1	A	1-3
18	660	67	3400	0.17	7.0	3.0	A	1-5½

[a] Approx.—Flow measurement beyond range of test set up at 2 in. static pressure.

[b] Test not carried to completion because exhaust remained visibly dusty during first 20 minutes of dusting.

[c] Clean and dirty rating the same because unit contains no filter to increase in resistance.

[d] Actual velocity is approximately 3 times higher because only about ⅓ of filter area is effective area.

[e] Air flow varies with water level: At high level flow is low and dust collection high; at low level, vice versa.

[f] Test terminated after 80 minutes dusting with very little decrease in flow.

[g] Lower than is allowable in New York State.

[h] Effluent dustiness rated by three observers on following basis: A—No dust through filter and no leakage around filter; B—No dust through filter but leakage around filter; C—Dust blows through filter but no leakage around filter; D—Dust blows through filter and leaks around filter.

Conclusions

These tests have shown a real need for a standardization of rating and sizing procedure because they have revealed a wide divergence between manufacturer's rated capacity (free flow into a clean unit) and actual usable capacity (flow through hoods and ducts into a dusted unit). For the protection of the purchaser, it would seem desirable that once a standardized rating procedure is adopted, either by the manufactur-

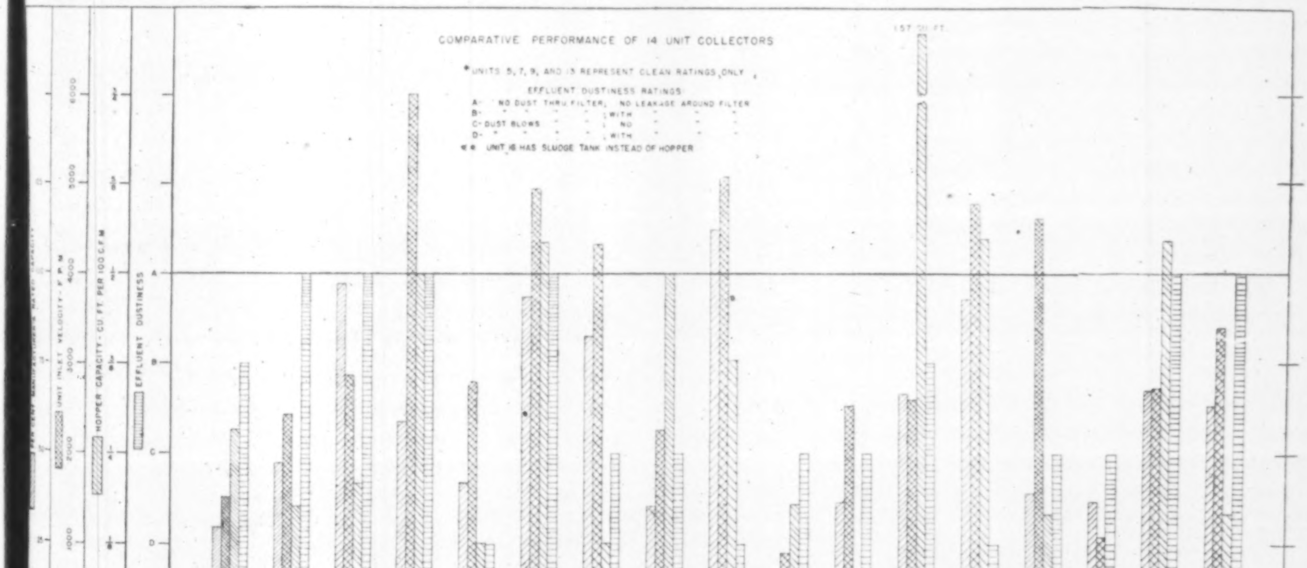


Fig. 10—Comparative performance of unit collectors

ers themselves or by the various state regulatory bodies, units be given nameplates rated from performance data based on such rating procedure.

Recirculation of air from a dust collector back into the workroom can be successfully accomplished only under exceptionally well controlled conditions. These tests have confirmed this conclusion, since only six of the eighteen units tested had a visible clean effluent and only one had an acceptable effluent dust count. In the remainder, appreciable dust either blew through the filter or leaked out around the filter. None of these latter units are acceptable for recirculation regardless of the adequacy of their air flow rating and inlet sizing. They might be useful, however, if provided with a discharge duct connection and adequate additional fan capacity so that the effluent could be discharged out of doors instead of back into the workroom.

Summary

1. A set of proposed standards specifications for unit dust collectors has been prepared.
2. A total of 18 collectors of 13 different makes have been tested against these standards.
3. In almost all cases, the collectors tested fell short of the proposed standards.
4. The need for adoption of standards for and improvement of design of unit dust collectors is apparent.

Appendix A

Under controlled conditions, it may be possible to allow recirculation from unit collectors whose effluent does have a higher dust count than the ambient atmosphere without such recirculation by setting up a sliding scale whereby the percentage of recirculation permitted decreases as the effluent dust count increases. A suggested set of standards for this control follows:

1. Maximum permissible recirculation for units having effluent dust count no higher than ambient without recirculation may be 1 cfm for every 10 cu ft of room volume. This limit is set to provide a factor of safety for improper maintenance, one example of which is the not uncommon practice of removing rather than replacing a dirty filter.)

2. Maximum permissible test dust count above which no recirculation would be permitted should be 3 mppcf in excess of ambient without recirculation when the unit is tested at a dust loading of 1.5 grains per cu ft by a dust having a mean size of 3μ on a particle count basis.

3. Maximum permissible recirculation for units having effluent dust count of 3 mppcf in excess of ambient air without recirculation under above test conditions should be 1 cfm for every 100 cu ft of room volume.

4. In the intermediate range an additional 10 cu ft per cfm could be allowed for each step of ⅓ mppcf above ambient without recirculation between 0 and 3 mppcf.

ASTM OCCUPIES NEW HEADQUARTERS

The headquarters of the *American Society for Testing Materials,* which for a number of years has been located at 260 S. Broad St., Philadelphia, moved into its permanent headquarters building at 1916 Race St., Philadelphia, May 1. This building was purchased and remodeled through contributions made by many companies and individuals active in the *ASTM's* work. The new building is strategically located on Philadelphia's parkway, adjacent to the Academy of Natural Sciences, close to the Franklin Institute and the main Philadelphia Free Library.

The annual meeting of the *ASTM* will be held June 24-28, 1946, at the Statler Hotel, Buffalo, N. Y., at which time there will be more than 200 meetings of the *ASTM's* technical committees and over 150 technical papers and reports by the country's leading authorities in the field of materials.

The Seventh Exhibit of Testing Apparatus and Related Equipment will be in progress and the Annual Photographic Exhibit also will be held.

LIBRARY BOOKS ACKNOWLEDGED

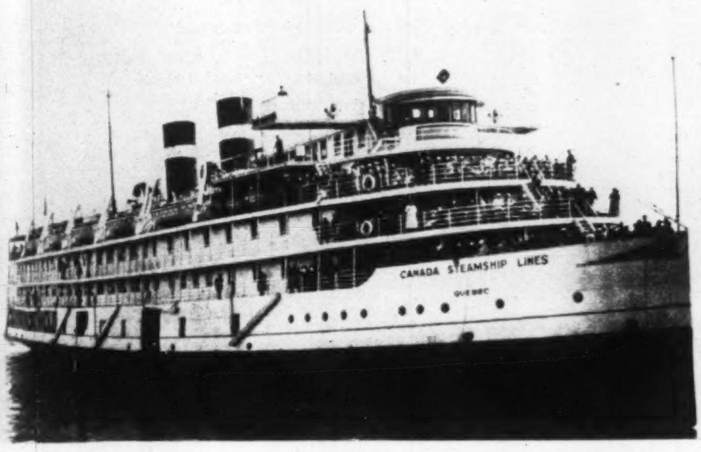
Contributions are still being received and welcomed at the John R. Allen Memorial Library, ASHVE Research Laboratory in Cleveland, Ohio, according to the Director of Research, Cyril Tasker.

The Committee on Research acknowledges with thanks the four recently acquired books listed which have been received for the library.

The establishment of the John R. Allen Memorial Library is to honor the pioneer work of one of the Society's past presidents and the first director of its Research Laboratory.

Members of the Society who have books, pamphlets and other printed material dealing with the arts and sciences of heating, ventilating and air conditioning are invited to contribute such matter. A special bookplate will be placed in each volume and all contributed volumes will bear the name of the donor. Contributions should be sent by parcel post or express collect to the Director, ASHVE Research Laboratory, 7218 Euclid Ave., Cleveland 3, Ohio.

TITLE	AUTHOR	DONOR
Design of Fans	F. H. Slade	J. B. Pinkerton
Engineering Designs for Replanning	J. B. Pinkerton	J. B. Pinkerton
High Pressure Hot Water Heating Systems	F. H. Slade	J. B. Pinkerton
Questions and Answers on Heating and Ventilating	J. B. Pinkerton	J. B. Pinkerton



S. S. Quebec

Semi-Annual Meeting Summer Cruise on St. Lawrence

Montreal

June 10, 11 and 12, 1946

THE Montreal Chapter will act as host for the 1946 Semi-Annual Meeting of the Society and has arranged for the rendezvous in Montreal June 10 and on board the *S.S. Quebec* June 11, 12 and 13.

Members have received two reservation forms through the mail, one for Hotel, Luncheon and Banquet reservations (*blue* form—to be returned to A. B. Madden, *chairman*, c/o Crane, Ltd., P. O. Box 130, Montreal, Que., Canada), and the other for the St. Lawrence River Cruise (*yellow* form—to be returned to Secretary, New York Headquarters Office, 51 Madison Ave., New York 10, N. Y.). The Committee on Arrangements will assist in getting Hotel reservations for early arrivals in Montreal. Tickets for the luncheon and Banquet may be picked up at the Registration desk. Members applying for Cruise tickets should indicate a first, second and third choice for accommodations.

F. A. Hamlet, general chairman of the Committee on Arrangements, reports that plans for the unique land and sea meeting are progressing satisfactorily. The meeting will open at the Mount Royal Hotel, Montreal, Monday morning, June 10, continuing aboard the *S.S. Quebec* sailing down the St. Lawrence to Quebec, Murray Bay, and Tadoussac, the gateway to the majestic Saguenay Fjords.

Registration will begin Monday morning at the Mount Royal Hotel. A welcome luncheon will be held in the Jacques Cartier Room, followed by the first session of the meeting.

Preceding the technical sessions there will be a meeting of the Council, the Committee on Research, and some meetings of the Technical Advisory Committees. It is planned to have three technical sessions, at which time papers on heating, air conditioning and research studies conducted at the Society's Research Laboratory and cooperating universities will be presented.

Montreal, the romantic French-English city, capital of Canada, has many landmarks of beauty and interest to the visitor. A sightseeing and shopping tour has been arranged for the ladies Monday afternoon.

Monday evening all will board the cruise ship *S.S. Quebec* and will set sail from Montreal at 6:45 p.m. Aboard ship are many facilities for the entertainment and relaxation of the guests, such as deck sports, tea dances, the traditional ship's concerts and *sing-song*. Dinner will be served in the ship's dining room, where new zest will be found in the enjoyment of the cuisine with its accent on French and French-Canadian dishes, as well as just good American bill of fare. At 8:30 there will be entertainment and dancing in the music room.

On Tuesday afternoon the *S.S. Quebec* will dock at Murray Bay and all will go ashore for sightseeing in this historic wonderland and scene of the earliest North American settlements. There will ~~be~~ opportunity at the Manoir Richelieu, a famous summer resort, for golf, swimming, tennis, lawn bowling and other sports. In the evening there will be a stopover at Tadoussac, the oldest fur trading post in North America and gateway to the Saguenay, which flows through the Laurentian mountains. The Saguenay is one of the world's most amazing rivers, a great fjord carved out of the wilderness during the glacial age, whose black waters are 600 ft deeper than the St. Lawrence, into which it flows. As you cruise into these majestic vistas

RATES FOR STEAMER ACCOMMODATIONS

(These rates include transportation tax)

	Per Person
Outside cabins, upper and lower berths—	
(U. S. funds)	$39.73
(Canadian funds)	43.70
Outside cabins, with private lavatory—	
(U. S. funds)	42.86
(Canadian funds)	47.15
*Outside cabins, with twin beds, toilet and private tub baths—	
(U. S. funds)	52.27
(Canadian funds)	57.50

*Limited number available.

you may well feel, as early explorers did, that you are discovering the fabled Northwest Passage.

Wednesday evening, on the return trip, the ship will stop at Quebec, America's only walled city, and the Semi-Annual Banquet will be held in the ballroom of the Chateau Frontenac.

The ship will sail from Quebec at 10:30 p.m., arriving at Montreal at 8:30 a.m., Thursday, June 13. This schedule will permit those who want to leave on early morning trains to make connections and those who drive to make an early start.

Entering Canada and Returning to U. S.

United States Citizens. No passports are required of United States citizens. However, each person should be prepared to answer satisfactorily questions by the Examining Immigration Officer to establish identity and residence. It would be helpful to have birth or baptismal certificate, voter's certificate, tax bills, letter of identification from a bank manager, personal letters, car license, driver's license or similar personal papers.

Naturalized Citizens. Citizens of the United States by naturalization should be prepared to present their naturalization certificates.

Foreign-born Members. It will be well for foreign-born members or those of foreign extraction to have in their possession birth certificates or any other identification.

Customs

Canadian and United States Customs officials examine all passengers' baggage when crossing the border, on trains or at terminal points. Merchandise valued up to and including $100 will be admitted free of custom charges.

RAIL AND PULLMAN RATES

First Class Round Trip Rates to Montreal

City	R.T. RR Fare in Pullman (Inc. Tax)	Lower Berth Pullman R. T. (Including Tax)
ATLANTA	$ 86.37	$24.15
BOSTON	25.42	6.78
BUFFALO	27.08	7.32
CHARLOTTE, N. C.	78.09	18.86
CHICAGO	60.43	15.99
CINCINNATI	58.88	17.48
CLEVELAND	43.64	12.54
COLUMBUS	53.25	17.48
DALLAS	111.50	33.36
DENVER	119.43	35.42
DES MOINES	80.85	22.77
DETROIT	40.14	10.70
HOUSTON	119.95	35.30
INDIANAPOLIS	61.18	17.48
KALAMAZOO	49.84	14.15
KANSAS CITY	86.60	24.04
LOS ANGELES	174.69	63.83
MEMPHIS	88.84	26.00
MILWAUKEE	65.32	15.99
MINNEAPOLIS	83.61	22.77
NEW HAVEN	27.99	6.78
NEW ORLEANS	105.05	34.04
NEW YORK	28.75	6.78
OKLAHOMA CITY	106.15	30.71
OMAHA	88.78	24.04
PHILADELPHIA	37.09	8.05
PITTSBURGH	48.93	13.80
PORTLAND, ORE.	163.01	57.96
ST. LOUIS	73.43	18.64
SALT LAKE CITY	145.48	43.36
SAN FRANCISCO	174.69	63.83
SEATTLE	163.01	57.96
SYRACUSE	21.28	6.78
TORONTO	24.96	5.75
WASHINGTON, D. C.	45.94	11.35
WINNIPEG	91.95	11.50

Exchange

A premium of 10 per cent is paid on American money when exchanged, so that $1.00 in American money is worth $1.10 in Canadian money.

COMMITTEE ON ARRANGEMENTS

F. A. Hamlet, *General Chairman.*

Leo Garneau, *Vice-Chairman.*

Banquet—A. B. Madden, *chairman;* J. B. Flanagan, G. L. Ballantyne.

Entertainment — T. H. Worthington, *chairman;* A. F. Lamontagne, Jack Wright.

Finance—F. G. Phipps, *chairman;* J. D. Ross, Clifford A. Booth.

Inspection—A. M. Peart, *chairman;* J. G. Chenevert, W. J. Orr.

Ladies—J. J. Cosgrove, *chairman;* A. E. Watts, F. A. Sheppard.

Publicity—W. G. Hole, *chairman;* E. H. Terrence, J. H. Storey.

Sessions—J. B. Dykes, *chairman;* B. J. Horsburgh, Ralph Grossman.

Reception—W. W. Timmins, *chairman;* J. P. Fitzsimons, John Colford.

Secretary—S. W. Salter.

AN INVITATION TO MEMBERS

The Meetings Committee wishes to encourage the authors who can and will prepare good technical papers for presentation to our Society. We are particularly interested in papers dealing with new or novel developments and which material can be incorporated into the literature and will assist others in the solution of current problems.

Any one of the committee members will be glad to consult by mail or otherwise with authors to predetermine whether the particular paper is desired and can be used. We need good papers on air conditioning of all kinds and new papers on air distribution, industrial hygiene and industrial ventilation.

Papers must be presented first to the Publication Committee for approval for publication and then are passed on to the Meetings Committee for selection to use at the Annual or Semi-Annual Meetings. We need papers planned now to take care of the Annual Meeting in January, 1947. If you have any papers you would like to suggest, please communicate with us.

THE MEETINGS COMMITTEE
Lester T. Avery, *Chairman*
F. W. Hutchinson
E. N. McDonnell

Tentative Program

American Society of Heating and Ventilating Engineers

Semi-Annual Meeting

Sunday, June 9

10:30 a.m. Guide Publication Committee

Monday, June 10

9:00 a.m. REGISTRATION (Mount Royal Hotel)
10:00 a.m. Council Meeting
12:15 p.m. Welcome Luncheon (Mount Royal Hotel, Jacques Cartier Room)
2:00 p.m. RESEARCH SESSION (Mount Royal Hotel, Jacques Cartier Room)
  Pres. Alfred J. Offner presiding
  Greetings by Pres. A. B. Madden, Montreal Chapter
  Response by President Offner
  Committee Reports
  Forced Convection Heat Transfer Coefficients Along a Smooth Flat Surface, by G. V. Parmelee and R. G. Huebscher
  Effect of Turbulence Promoters on Film Coefficients for Water Inside Tubes, by L. G. Seigel
  Energy Losses at Suction Hoods, by A. D. Brandt and R. J. Steffy
  Characteristics of Unit Dust Collectors, by A. C. Stern, Jack Baliff, A. E. Perina, Robert Crowley, Benjamin Feiner and A. A. Urbano
2:15 p.m. Ladies' Sightseeing Trip and Shopping Tour
5:30 p.m. All Aboard *S.S. Quebec* for Cruise on St. Lawrence River
6:45 p.m. Leave Montreal
7:00 p.m. First Call for Dinner
8:30 p.m. Entertainment and Dancing in Music Room of Steamer

Tuesday, June 11

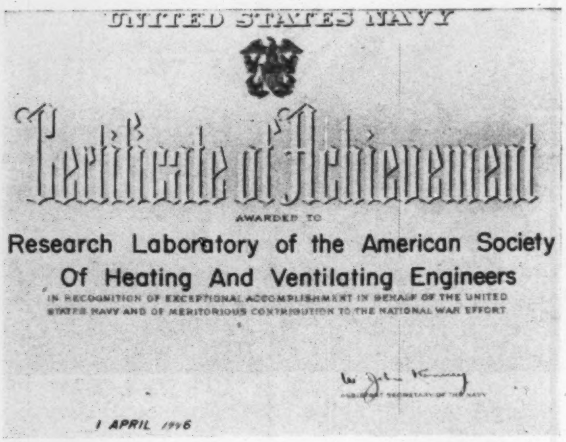
7:30 a.m. *S.S. Quebec* Leaves Quebec for Murray Bay
9:30 a.m. AIR CONDITIONING SESSION (*S.S. Quebec,* Music Room)
  Air Conditioning of a Canadian Windowless Textile Mill, by G. Lorne Wiggs
  The Sol-Air Thermometer—A New Instrument, by C. O. Mackey and L. T. Wright, Jr.
  Periodic Heat Flow—Composite Walls or Roofs, by C. O. Mackey and L. T. Wright, Jr.
  Heat Losses Through Wetted Walls, by E. C. Willey
12:00 p.m. Arrive Murray Bay for Sightseeing, Swimming, Golf, Tennis at Manoir Richelieu
3:30 p.m. All Aboard for the Saguenay
4:00 p.m. Chapter Delegates Meeting
7:00 p.m. Sightseeing at Tadoussac
9:00 p.m. Entertainment and Dancing

Wednesday, June 12

1:00 a.m. Leave Bagotville
9:30 a.m. HEATING SESSION (*S.S. Quebec,* Music Room)
  A Rational Basis for Solar Heating Analysis, by F. W. Hutchinson and W. P. Chapman
  Hold-Fire Controls for Bituminous Coal Stokers, by C. C. Wright, T. S. Spicer and H. A. Baumann
  Influence of an Interior Coating of Aluminum Paper in Internal Thermal Conditions and Heat Economy, by R. J. Lorenzi, L. P. Herrington and C.-E. A. Winslow
2:00 p.m. Deck Sports and Games
2:30 p.m. Nominating Committee Meeting
7:30 p.m. Banquet (Chauteau Frontenac, Quebec)
10:30 p.m. Leave Quebec

Thursday, June 13

8:30 a.m. Arrive Montreal



UNITED STATES NAVY

Certificate of Achievement

AWARDED TO

Research Laboratory of the American Society Of Heating And Ventilating Engineers

IN RECOGNITION OF EXCEPTIONAL ACCOMPLISHMENT IN BEHALF OF THE UNITED STATES NAVY AND OF MERITORIOUS CONTRIBUTION TO THE NATIONAL WAR EFFORT

ASSISTANT SECRETARY OF THE NAVY

1 APRIL 1946

Pres. A. J. Offner is pleased to announce that the Navy's Certificate of Achievement has just been awarded to the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. The award, made in lieu of the Navy *E*, signalizes the *recognition of exceptional accomplishment in behalf of the United States Navy and of meritorious contribution to the national war effort*.

Early in the war it became evident to the Navy that if the men *fighting its ships* were to be efficient, a number of problems concerned with the reaction of the men to conditions of heat, humidity and noise would have to be solved. Among the problems undertaken by the Research Laboratory were Cooling Requirements of Aviator Ready Rooms on Aircraft Carriers, Spot Cooling of Workers in Engine and Fire Rooms and several others concerned with physiological and psychological effects of temperature and noise.

The Society made its research facilities available to the United States Government for this work, which was done under the direction of the Society's Committee on Research and a number of Technical Advisory Committees. Extremely valuable data resulted which provided improvements in design of heating, ventilating and air conditioning systems in naval vessels.

These studies were carried on at the Research Laboratory, then located at the Bureau of Mines, Pittsburgh, Pa., the director being the late Commander F. C. Houghten, USNR. The Society's Laboratory is now established at 7218 Euclid Ave., Cleveland 3, Ohio, in its newly acquired building with Cyril Tasker, director of research, in charge.

INTERNATIONAL JOINT COMMITTEE ON PSYCHROMETRIC DATA

At its next meeting the International Joint Committee on Psychrometric Data will concern itself with the thermodynamic properties of moist air in accordance with an agenda prepared by a subcommittee consisting of Dean John A. Goff and S. Gratch, instructor in mechanical engineering, Towne Scientific School, University of Pennsylvania; Dr. C. S. Cragoe, chief, Heat Measurements Section, National Bureau of Standards; Dr. L. P. Harrison, chief, Technical Investigations Section, U. S. Weather Bureau, and Dr. F. G. Keyes, professor of chemistry, MIT.

The International Joint Committee on Psychrometric Data was formed under the sponsorship of the ASHVE at the Society's 52nd Annual Meeting in 1945 at Boston. The primary objective of the committee is to establish standard tables on the properties of air and water vapor mixtures, for adoption as an international standard, eliminating the discrepancies in the values which exist in the several tables now in use.

The following organizations are participating: Canada—Department of Transport, Meteorological Division; National Research Council; Great Britain—*Institution of Heating and Ventilating Engineers*; National Physical Laboratory; *The Physical Society*; United States—*American Institute of Chemical Engineers; American Physical Society;* AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS; *American Society of Mechanical Engineers; American Society of Refrigerating Engineers;* Department of Commerce, National Bureau of Standards; Weather Bureau; War Department, Signal Corps.

FRENCH IN CHARGE OF CARRIER CORP. ENGINEERING

Donald French, vice-president, has been placed in charge of the engineering division of Carrier Corp., Syracuse, N. Y., succeeding Herbert L. Laube who has resigned to establish his own business.

Mr. French has been with Carrier Corp. since 1930, directing research and development, was elected vice-president in 1934, and has been head of the staff division, in which position he will continue in addition to his new activity. He has been a member of the ASHVE since 1926.

LIGE APPOINTED CHICAGO BRANCH MANAGER

Walter W. Lige, a member of the ASHVE, has been appointed manager of the Chicago branch office for Penn Electric Switch Co., Goshen, Ind., to succeed E. B. Maire, resigned, according to announcement by R. H. Luscombe, sales manager.

Mr. Lige was formerly associated with Montgomery Ward & Co. and Bell & Gossett Co. In addition he has had considerable experience as a consulting engineer and as branch heating manager for Crane Co.

JOHNSON SERVICE ELECTS OFFICERS

The board of directors of the Johnson Service Co., Milwaukee, Wis., elected officers for the ensuing year. Re-elected were H. W. Ellis, Milwaukee, chairman of the board; J. A. Cutler, Milwaukee, president and general manager; and O. G. Ward, Chicago and M. F. Rather, New York, vice-presidents. R. J. Murphy, Milwaukee, was elected secretary and treasurer; J. R. Vernon, Milwaukee, assistant secretary, and L. V. Zachary, Milwaukee, assistant treasurer.

S. F. Johnson, Altadena, Calif., grandson of the founder of the company was elected to the board of directors. C. P. Vogel, E. W. Hoffman and A. J. Otto, Milwaukee, C. F. Johnson, Reno, Nev., and R. M. Henry, Evanston, Ill., were re-elected as directors.

Messrs. Ellis, Cutler, Ward and Rather have been members of the ASHVE for over twenty-five years and Mr. Vernon joined the Society, in 1926.

MAURICE T. FIRESTONE WITH AMERICAN COAL CO.

M. T. Firestone has been appointed executive vice-president of the American Coal Co., Hartford, Conn. as announced by Pres. C. J. Sheketoff.

Mr. Firestone was born in Leeds, Yorkshire, England and lived in Canada for 5 years. He studied engineering at McGill University, Montreal and law at Northeastern University, Boston, Mass. He was employed by General Electric Co., Lynn, Mass. and for the past 21 years has been with Carrier Corp. in Philadelphia, New York and New England areas. He is a member of the Society and also a member of the *American Society of Refrigerating Engineers.*

DEVELOPMENT ENGINEER APPOINTED BY BITUMINOUS COAL RESEARCH

Dr. Harold J. Rose, vice president and director of research of Bituminous Coal Research, Inc., Oliver Bldg., Pittsburgh, Pa., has announced the appointment of W. S. Major of Philadelphia, Pa., as development engineer for the national research agency of the bituminous coal industry. The new development engineer will deal at first largely with industrial and commercial equipment designed to provide improved utilization of bituminous coal.

Mr. Major, a graduate of Lehigh University, Bethlehem, Pa., where he received a Bachelor of Science degree in chemical engineering in 1924, first engaged in research work on the briquetting of coal. In 1925 he joined the staff of American Engineering Co., and was district manager at Cincinnati, Ohio, from 1928 through 1929, at which time he was appointed district manager at Chicago, where he served until 1941. In August of that year he was transferred to Philadelphia as assistant to the general sales manager, American Engineering Co., to supervise district offices and agencies, prepare sales manuals, as well as analyses and reports on fuel economies for industrial power plants, conduct sales engineering, and became sales manager of its power plant division, which position he held until he joined the BCR staff.

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THEODORE WEINSHANK, LIFE MEMBER, DIES IN CHICAGO

Theodore Weinshank, age 83, Life Member of the ASHVE, died in Chicago, March 21, 1946. He was born in Russia, August 15, 1862, and came to the United States when a young man. He obtained his M.E. degree from the University of Illinois and served his apprenticeship at Maltley and Wallace, Champaign, Ill. In 1896 he became connected with the B. F. Sturtevant Co., Chicago; then with the Warren Webster Co. and later associated himself with S. E. Fenstermaker under the firm name of Weinshank & Fenstermaker, mechanical heating and ventilating engineers, Indianapolis, Ind. In 1934 he opened his own office as consulting engineer in Chicago. Mr. Weinshank had many important jobs to his credit in his long and active career.

He served this country during World War I, and during that time was a member of the Board of Fuel Conservation for the Government.

He was also a member of the *American Society of Mechanical Engineers,* and the *Society of American Military Engineers.* He joined the ASHVE in 1906 and was an active, outstanding member, serving in office both locally and nationally. He was a member of the Board of Governors in 1913 and was elected to Life Membership in 1933.

At the Semi-Annual Meeting of the Society in 1908 he presented a paper on Cast Iron Heaters for Hotblast Work, which was published in the Society's TRANSACTIONS and contributed by participation in discussions of many other papers. He was an ardent believer in the Society and its work and did a great deal in interesting others to become members. This interest persisted until the end, notwithstanding that due to illness he could not actively participate the last few years. In 1928 he donated his entire library of all Proceedings of *ASME* and ASHVE to the International University of Jerusalem, Palestine.

The Council and Officers of the Society mourn the loss of their fellow member and extend their deepest sympathy to his family.

KENNETH C. WOODWARD OF CHASE BRASS DIES

It is with profound sorrow that we learn of the death of Kenneth C. Woodward, who died of a heart ailment at Meriden, Conn., February 11, at the age of 55.

Mr. Woodward was born December 18, 1890, in Newton, Mass., where he received his elementary and secondary education. In 1911 he graduated from the United States Naval Academy at the age of 21. He was employed with the Boston Elevated Railway, 1911 to 1913; with Grinnell Co., Providence, R. I., 1913 to 1919. He was vice president of the C. N. Flagg & Co., Inc., Meriden, Conn., until 1931, when he went into business for himself under the firm name of Kenwood Associates, Consulting Engineers, Meriden, Conn. In 1943 he became connected with Chase Brass & Copper Co., Waterbury, Conn., where he worked until the time of his death. During his career he designed some very large and successful heating and ventilating installations and has many successful installations to his credit. At the Chase plant he had a very essential part in the compilation of the Chase Radiant Heating Manual and spent a considerable portion of his time in giving lectures and helping with design data on the subject of radiant heating.

He was a popular and active member of the Connecticut Chapter, ASHVE; also a prominent member of the Lions Club in Meriden, and was a great fishing enthusiast. His loss will be keenly felt by his many friends and fellow members in the society.

The Officers and Council of the Society extend their deepest sympathy to his widow, Audrea; his three daughters, Janet, Audrea and Lucille, and one grandson.

SUMMARY OF LOCAL CHAPTER MEETINGS*

Central Ohio—March 18. Subject: Selecting the Type of Heating System for a Housing Project. Speaker: P. A. Croney, Boston, Mass. The talk was followed by an interesting question and answer period. J. H. Jennings, Columbus, Ohio, and A. M. Rosenblatt, Charleston, W. Va., were elected members of the chapter. Attendance, 53.

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Cincinnati—March 12. Subject: Heat Transfer Surface as Applied to Automobile Radiators. Speaker: L. P. Saunders, chairman, Committee on Research, ASHVE. Mr. Saunders carried the complete development of this type of equipment through its various steps and presented technical data and test curves to demonstrate. He had a very complete file of plates which were projected on the screen to illustrate and confirm his talk. Due to the small attendance, Chairman Richard announced an open meeting and the entire group gathered at the table to ask questions. Attendance, 14.

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Connecticut—March 21. Subject: The Value of Air Conditioning in Precision Manufacturing. Speaker: Mr. Tutt. Mr. Tutt's talk was of great interest to the entire group. Some extremely pertinent data on installation costs and benefits resulting from air conditioning were illustrated by the speaker.

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Delta—April 3. Subject: Activated Sludge Sewage Disposal Plant: Speaker: R. K. Rothrock, a member of Delta Chapter. The talk was illustrated by slides and followed by an interesting question and answer period. A rising vote of thanks was given Mr. Rothrock for an excellent talk. H. A. Salaun was introduced as a new member. An added feature of the program was the showing of three films secured by the entertainment committee. Attendance, 26.

Delta—March 7. Subject: Fundamental Causes of Accidents. Speaker: Arthur Naquin, safety counselor. Mr. Naquin's talk was received with great interest and was followed by many questions from those present. Pres. W. H. Grant, Jr., introduced Mr. I. W. Mann, Jr., a new member of the Society. The concluding feature of the program was the showing of three entertaining sports films. Attendance, 23.

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Golden Gate—March 20. Subject: Industrial Air Conditioning. Speaker: D. L. Williams, General Air Conditioning and Heating Co. He stated that due to urgent necessity and unlimited finances during the war years, the number of new applications of industrial air conditioning had been increased enormously. Mr. Williams gave many interesting illustrations of the application of air conditioning to manufacturing processes. Attendance, 49. Attendance ratio, 0.5[illegible]

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Illinois—March 11. Subject: Design and Control of Year 'Round Comfort Air Conditioning Systems. Speaker: William Goodman, consulting engineer and professor of mechanical engineering, Illinois Institute of Technology. Arthur G. Stout, assistant chief mechanical engineer, Holabird and Root, conducted the question and answer period following Professor Goodman's talk. Attendance, 120. Attendance ratio, 0.68.

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Kansas City—April 2. Subject: Axial Flow Fans. Speaker: R. S. Reade, Jr., manager, Industrial Engineering Division, American Blower Corp., Detroit. Mr. Reade presented an illustrated talk, giving a full and complete description of the characteristics, engineering and application of axial flow fans. An active question and answer period followed. Another feature of the meeting was the showing of a film on wrought iron and pipe making. Attendance, 70.

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Manitoba—March 26. No business was conducted at this meeting as this was the Annual Mixed Party of the chapter, with C. G. Davis, chairman of the Entertainment Committee, presiding. Attendance, 55.

Manitoba—February 21. The entire time of the meeting was given to chapter business. Reports of the National Annual Meeting were given by F. T. Ball and Einar Anderson. The reports covered impressions of all the sessions of the delegates and were of considerable interest to the members. Attendance, 19.

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Memphis—March 4. Subject: Central System of Heating and Cooling for Industrial and Domestic Services. Speaker: Orion O. Oaks, chief engineer, John B. Pierce Foundation, Raritan, N. J. After an interesting talk, a round table discussion followed. Attendance, 28. Attendance ratio, 0.9.

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Minnesota—March 4. Subject: Heat Transfer from Direct Fired Heating Surfaces. Speaker: Prof. L. G. Miller, head, department of mechanical engineering, Michigan State College. Professor Miller's talk was very interesting. It was illustrated by slides covering curves and experimental data. He also made some predictions on the development and cost of warm air furnaces for low cost housing. A discussion period followed the talk at which time Professor Miller answered a number of questions. Attendance, 63.

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Montreal—March 18. Subject: Electronics. Speaker: A. M. Peart, district manager, Minneapolis-Honeywell Regulator Co., Montreal. In conjunction with the talk three sets of interesting movies were presented. These films were the same as used in the U. S. Army

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*Note. The attendance ratios shown represent the membership attendance divided by the chapter membership. These ratios will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by the various chapters and may be useful in deciding on subjects for chapter meetings.

Training Program for the Air Force—simplified Disney educational features. Attendance, 36.

A very successful curling bonspiel was held on March 4th at the Caledonia Curling Club, Montreal. This is an annual Montreal Chapter affair. Eight teams of four men each participated. The 1945-46 winners were Jack Wright, S. W. Salter, A. M. Peart and J. Hannigan.

MONTREAL—February 18. The entire meeting was devoted to round table discussion pertaining to chapter business and plans for the Semi-Annual Meeting of the Society to be held at Montreal, June 10-12. Attendance, 33.

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NEBRASKA—April 10. The entire time was devoted to chapter business; discussion of the trip to the Semi-Annual Meeting at Montreal and election of officers. Attendance, 11. Attendance ratio, 0.38.

NEBRASKA—March 12. Subject: Wrought Iron. Speaker: W. B. Simpson, district manager, A. M. Byers Co. An interesting film, *Eternally Yours*, a story of wrought iron, was presented. The ancient history of wrought iron and early and modern methods of manufacture were shown by means of a sound film. Many uses of the metal were given as well as reasons for its ability to withstand corrosion. During the discussion period Mr. Simpson talked on the use of wrought iron pipe in radiant heating of homes, and Henry Kleinkauf of the Nebraska Chapter gave some of his findings with this type of heating in his home. Attendance, 31. Attendance ratio, 0.42.

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NEW YORK—April 15. Subject: Design and Development of Axial Flow Fans and Their Application to Air Conditioning, Combustion and Ventilation. Speaker: Adam Currie, chief engineer, research and development, L. J. Wing Mfg. Co. The talk was illustrated with slides showing performance, design procedure and typical installations of axial flow fans. Mr. Werner Hahne, research engineer, Cargocaire Engineering Co., presided at a question period during which Mr. Currie answered questions presented by the audience. A rising vote of thanks was given to Mr. Currie for a very interesting and instructive presentation. Attendance, 105. Attendance ratio, 0.41.

NEW YORK—March 18. Subject: Radiant Heating. This subject was discussed under the following headings by four speakers: Recent Developments in Radiant Heating Practice, C. A. Hawk, Jr., A. M. Byers Co., Pittsburgh; Installation Details; P. B. Gordon, Wolff and Munier, Inc., New York City; Current Methods of Application, J. K. M. Pryke, associate consulting engineer, Myers, Fuller and Addington, New York City; Designing for Comfort, R. G. Vanderweil, project manager, Chase Brass & Copper Co., Waterbury, Conn. Prof. Carl F. Kayan presided at the question period during which the speakers answered questions directed to them by the audience. Attendance, 200. Attendance ratio, 0.28.

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NORTH CAROLINA—April 12. Subject: Crisis of Our Times. Speaker: Hugo King, former mayor of Greensboro and recently discharged from the Navy as a lieutenant commander. His subject was non-technical but enjoyed by everyone. President Selden welcomed and especially recognized a fellow member, William Sullivan, Sr., also a former mayor of Greensboro. An added feature of the program was a magician act by F. E. P. Klages, district manager, The Powers Regulator Co. Attendance, 36. Attendance ratio, 0.53.

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NORTH TEXAS—March 18. Subject: Building Codes for the City of Dallas. Speaker: L. A. Bickel, executive assistant, Lone Star Gas Co. After the talk P. N. Vinther, member of the building codes committee for the City of Dallas, conducted a discussion period. This subject was enthusiastically received by the group. Attendance, 50. Attendance ratio, 1.77.

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OREGON—April 4. Subject: Panel Heating. Speaker: Ernie Weber, Seattle. In his talk Mr. Weber used slides illustrating the methods of installation. Prof. E. C. Willey, mechanical engineering department, Oregon State College, reported on research to determine the heat loss through a wet wall. Attendance, 81.

OREGON—March 7. Subject: Automatic Controls for Panel Heating. Speaker: G. D. Guler, sales manager, air conditioning controls division, Minneapolis-Honeywell Regulator Co. Attendance, 61.

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PITTSBURGH—April 8. Subject: Radiant Heating. Speaker: William Mulholland, Chase Brass and Copper Co. This subject was of great interest to all present. Mr. Mulholland showed slides which illustrated radiant heating from the early days to the present methods of installing copper tubing in the floor, walls and ceiling. A very interesting discussion period followed where many questions were asked the speaker regarding expansion, cracking and others.

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ROCKY MOUNTAIN—April 3. The entire time was spent on chapter business. Retiring Pres. G. D. Maves relinquished the chair to President-elect F. L. Adams.

ROCKY MOUNTAIN—March 6. Subject: Forced Air Heating. Speaker: Norris M. Blanchard, engineer and western sales manager, L. J. Mueller Furnace Co., Milwaukee. Mr. Blanchard's talk covered register locations, air velocities, zoned systems, high registers *vs.* low registers, limit and blower control setting and related subjects. In discussing this subject he stated that the prime requirement of a heating job is comfort and stressed the importance of having a furnace sized *on the nose*, rather than oversized, so as to give longer fuel and blower *on* periods. An interesting discussion period followed. Attendance, 77. Attendance ratio, 1.18.

ROCKY MOUNTAIN—February 6. Subject: Fire Hazards of Heating and Ventilating Systems. Speaker: D. G. Mulligan, engineer, Mountain States Inspection Bureau. Mr. Mulligan pointed out the fire hazards of improperly constructed and inadequately protected duct systems, even though they are installed in fireproof buildings, and precautions to be observed. An interesting question and answer period followed. Attendance, 32. Attendance ratio, 0.49.

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South Texas—March 15. Subject: Engineered Air Distribution. Speaker: Vic Lathers, Barber Colman Co. A. F. Houston gave a brief report on the activities of the Houston Engineers Council. Mr. Lathers gave a very interesting talk which was followed by a discussion period. Attendance, 69.

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Southern California—March 13. Subject: Heating and Air Conditioning by Reverse Cycle. Speaker: F. W. Jordan, manager, Pacific Coast Franchise Contractors, Westinghouse Electric Corp. Slides were used with the presentation of the subject and extreme interest was shown in the discussion which followed. The speaker stated that reverse cycle is particularly adaptable and shows great promise in the milder climates such as southern California. Attendance, 93.

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St. Louis—March 5. Subject: Modulating Flow. Speaker: B. C. Simons, branch manager, Minneapolis-Honeywell Regulator Co. In presenting this subject Mr. Simons showed two sets of talking slides, *Seven Keys to Comfort* and *Personalized Heat Control*. He explained that modulating flow as a method of heat control was not particularly new and that it simply meant the control of various types of heating systems so that an amount of heat in proportion to that lost was constantly being supplied into the areas being heated instead of depending on temperature fluctuations. After his talk Mr. Simons led a general discussion on various types of controls and their ramifications. Appreciation was expressed by President Oonk for the excellent talk by Mr. Simons and the very entertaining program presented at this meeting. Attendance, 46.

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Washington—March 13. Subject: Fan Sound Levels and Selection. Speaker: T. A. Walters, director of research, American Blower Corp. An additional feature of the evening was the showing of a movie featuring the Bell Telephone orchestra with Donald Voorhees, conductor, and Josef Hoffman, pianist. Mr. Walters gave a most interesting talk which was greatly appreciated by all those present. Attendance, 45. Attendance ratio, 0.32.

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Western Michigan—March 18. The largest meeting in the history of the Western Michigan Chapter assembled at a dinner meeting in the Union Building, Michigan State College, in connection with the 15th annual warm air short course at the college. Subject: History and Development of the Vaporizing Burner. Speaker: M. F. Coates, Duotherm Division, Motor Wheel Corp. He stated that the following conditions are essential for good operation: (1) A good chimney that would give approximately 6/10 in. draft at burner; (2) Clean oil; (3) Burner must level; (4) There should be no down drafts. Attendance, 359. Appreciation was expressed to the speaker and to Prof. L. G. Miller and Prof. C. H. Pesterfield, who did an excellent job in making arrangements for this large group.

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Western New York—March 11. The entire meeting was devoted to chapter business, discussion of ways and means to increase membership and the joint meeting with the Toronto Chapter in April. Attendance, 39.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month, 53 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by June 10, 1946, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

Allen, Charles G., Engr., Bryant Heater Co. **Proposers**: John Richmond, J. M. Black. **Seconders**: N. H. Hall, W. R. Teller.

Allen, Robert F., Engr., Carrier Corp. **Proposers**: D. D. Wile, J. H. Carpenter. **Seconders**: J. P. Stewart, W. S. Ramseaur.

Allen, William W., Jr., Branch Mgr., Owens-Corning Fiberglas Corp. **Proposers**: R. E. Gorgen, Lyman Gross. **Seconders**: J. E. Haines, H. C. Mills.

Allison, H. H., Specification Engr., United Rexall Drug Co. **Proposers**: Maron Kennedy, Art Theobald. **Seconders**: R. A. Lowe, A. J. Horn.

Atkinson, Russell R., Central Supply Co. **Proposers**: G. H. Risley, E. A. Murhard. **Seconders**: J. B. Banks, E. W. Neubauer.

Bodinus, William S., Branch Mgr., Carrier Corp. **Proposers**: A. G. Stout, Henry Lauterbach, Jr. **Seconders**: H. E. Rex, F. L. Gray, Jr.

Bonebrake, John H., Asst., J. Donald Kroeker. **Proposers**: J. D. Kroeker, R. C. Chewning. **Seconders**: T. E. Taylor, W. R. Norte.

Brown, Donald A., Vice-Pres., Texas Engineering Co., Inc. **Proposers**: A. F. Barnes, R. F. Taylor. **Seconders**: D. S. Cooper, W. E. Long.

Burr, L. R., Chief Engr., Kold-Hold Manufacturing Co. **Proposers**: William Goodman, L. J. Crisman. **Seconders**: C. H. Reynolds,* C. K. Davis.*

Capps, Edgar L., Comm'l Sales Mgr., R. F. Trant, Inc. **Proposers**: R. C. Thomas, W. H. Webster, Jr. **Seconders**: J. L. Grigg, J. F. Reynolds. *(Reinstatement & Advancement)*

EVANS, DAVID A., Engr., National Tube Co. PROPOSERS: T. M. Dugan, E. S. Tower. SECONDERS: W. H. Bateman, Van A. Reed, Jr.

FRANKHOUSER, ELMER V., Supt. of Power, Radio Corporation of America. PROPOSERS: S. E. Plewes, L. P. Hynes. SECONDERS: Edwin Elliot, M. G. Kershaw.

GARDNER, C. ROLLINS, Vice-Pres., Martyn Brothers, Inc. PROPOSERS: A. B. Ullrich, Jr., L. S. Gilbert. SECONDERS: P. N. Vinther, R. K. Werner. *(Advancement)*

GRIM, FREDERICK, Service Engr., Hajoca Corp. PROPOSERS: F. L. Doering, L. A. Bernert.* SECONDERS: J. W. Whiteride,* C. L. Overstreet.*

GUY, JOHN A., Htg. & Plbg. Engr., Saver Co., Inc. PROPOSERS: M. R. Hamlin, Thomas Aitken. SECONDERS: H. R. Allonier, R. W. Pirrung.

HARRIS, ROBERT C., Sales Engr., Minneapolis-Honeywell Regulator Co. PROPOSERS: K. R. Maganell, M. J. Olson. SECONDERS: B. G. Peterson, C. A. Carter.

HOLLINGWORTH, CHARLES E., Gen. Mgr., Baker Ice Machine Co., Inc. PROPOSERS: A. J. Hess, M. C. Greiner. SECONDERS: R. A. Lowe, R. M. Storms.

HOPPIN, CHARLES A., SR., Mgr., Sales Engrg. & Research, Laclede Gas Light Co. PROPOSERS: D. J. Fagin, M. A. Disney. SECONDERS: C. H. Burnap, H. C. Sharp.

HULL, JOHN J., Asst. Service Mgr., The Bridgeport Gas Light Co. PROPOSERS: F. F. Equi, J. R. Smak. SECONDERS: E. R. Clement, Sr., R. M. Toucey.

JACKETT, LYNN H., Engr., McGeorge, Hargett & Associates. PROPOSERS: L. E. Slawson, R. L. Byers. SECONDERS: T. D. Dravage, E. W. Gray.

JACKSON, ROBERT O., Sales Engr., Jackson Engineering Co. PROPOSERS: S. E. Fenstermaker, Jr., C. H. Hagedon. SECONDERS: R. H. Janitz, H. V. Alexander.

JAHN, WILLIAM E., Instructor, University of Minnesota. PROPOSERS: A. B. Algren, F. B. Rowley. SECONDERS: H. C. Mills, R. C. Jordan.

JENKINS, RAYMOND L., Cons. Mech. Engr. PROPOSERS: R. F. Taylor, C. C. Quin. SECONDERS: D. M. Mills, I. A. Naman.

JOHNSON, RAYMOND L., Asst. Hd., Research Dept., Young Radiator Co. PROPOSERS: F. H. E. Weil, E. H. Stempel. SECONDERS: W. E. Rheault, H. F. Brinen. *(Advancement)*

JONES, CHARLES D., Mgr., Charles D. Jones & Co. PROPOSERS: D. M. Allen, P. C. Leffel. SECONDERS: S. L. Furber, W. A. Reichow.

KLINE, FRANCIS L., Gas Engr., Iowa Power & Light Co. PROPOSERS: R. K. Smith, B. E. Landes. SECONDERS: C. A. Wheeler, W. W. Stuart.

LEWIS, HAROLD H., Partner, Gieske Sheet Metal Co. PROPOSERS: L. P. Heaven, R. B. Mason. SECONDERS: Carl Clegg, P. C. Leffel.

LUBINSKY, RICHARD G., Mgr., Fan & Blast Coil, The Trane Co. PROPOSERS: R. H. Anderegg, R. N. Trane. SECONDERS: S. G. Swisher, L. W. Hessler.

LUCEY, RAY E., Mgr., Prod. Engrg. Dept., The Trane Co. PROPOSERS: R. H. Anderegg, R. N. Trane. SECONDERS: S. G. Swisher, L. W. Hessler.

LUNDBERG, OLOF A., Htg. Contractor. PROPOSERS: Leo Hungerford, R. J. Peterson. SECONDERS: J. B. Venneman, R. A. Lowe.

MANDELL, LEONARD, Owner, Heataf Engineering. PROPOSERS: W. H. Jones, A. L. Hesselschwerdt, Jr. SECONDERS: James Holt, J. R. B. Mallik.

MANDELL, LOUIS D., JR., Asst. Sales Mgr., C. A. Dunham Co. PROPOSERS: O. J. Prentice, C. M. Brigham. SECONDERS: C. A. Thinn, W. C. Zingheim.

MILLER, ORVILLE, JR., Sales Engr., Owens-Corning Fiberglas Corp. PROPOSERS: A. O. May, J. S. Locke. SECONDERS: C. M. Burnam, Jr., Harry Himelblau.

MOODY, WILLIAM D., Vice-Pres., Barber Plumbing Co., Inc. PROPOSERS: A. F. Barnes, G. J. Collins. SECONDERS: D. M. Mills, B. F. Fisher.

NACHLAS, OTTO M., Partner, Ben Cash & Co. PROPOSERS: J. A. Walsh, C. L. Boehler. SECONDERS: Norman Way, W. J. Way.

PENDLETON, MORRIS E., Dist. Mgr., Armstrong Cork Co. PROPOSERS: Herman Seelbach, Jr., S. W. Strouse. SECONDERS: D. J. Mahoney, S. M. Quackenbush.

POGUE, ROGER B., Mech. Engr., Samuel R. Lewis. PROPOSERS: S. I. Rottmayer, S. R. Lewis. SECONDERS: E. P. Heckel, R. W. Shields.

POWITZKY, CALVIN E., Asst. Mgr., Jamar-Olmen Co. PROPOSERS: C. L. Boehler, J. A. Walsh. SECONDERS: C. W. Ellis, D. M. Mills.

RINGQUIST, CLARENCE L., Air Cond. Dept. Mgr., The Trane Co. PROPOSERS: R. H. Anderegg, R. N. Trane. SECONDERS: S. G. Swisher, L. W. Hessler.

SALE, GORDON N., Supvsr., Dominion Oxygen Co., Ltd. PROPOSERS: W. A. Duncan, R. J. Anderson. SECONDERS: L. M. Price, E. A. Creswick.

SAUNDERS, M. G., JR., Scheduling Engr., The Bahnson Co. PROPOSERS: Arvin Page, James Marshall. SECONDERS: Karl Selden, Jr., E. S. deWitt.

SCHULTZ, CLYDE W., Mgr., Htg. Dept., Crane Co. PROPOSERS: B. G. Peterson, D. D. Williams. SECONDERS: C. A. Carter, W. J. Hartwig.

SCURLOCK, ULVAN M., Owner, Bill Scurlock Air Conditioning & Heating Service Co. PROPOSERS: M. M. Rivard, David Caleb. SECONDERS: Gustav Nottberg, Henry Nottberg, Jr.

SIMPSON, JOHN A., Archt. PROPOSERS: F. T. J. Miller, R. C. Thomas. SECONDERS: W. H. Webster, Jr., J. L. Grigg.

SODERBORG, G. LLOYD, SR., Mgr., Engineering Sales Co. PROPOSERS: G. C. Campbell, R. C. Brown. SECONDERS: E. V. Gritton, D. R. Wilde.

STEVENSON, DANIEL B., JR., Engr., Newcomb & Boyd. PROPOSERS: H. K. McCain, S. W. Boyd. SECONDERS: F. W. Bull, W. J. McKinney.

TAPPEN, MELVIN M., Sales Engr., Johnson Service Co. PROPOSERS: C. A. Wheeler, R. K. Smith. SECONDERS: Perry La Rue, W. W. Stuart.

THOMAS, RALPH C., Pres., Thomas Air Conditioning, Inc. PROPOSERS: W. H. Webster, Jr., W. J. Gorsuch. SECONDERS: J. F. Reynolds, J. L. Grigg.

WARNER, JENNINGS B., Naval Archt., Norfolk Naval Shipyard. PROPOSERS: W. J. Gorsuch, K. E. Beisel. SECONDERS: W. H. Webster, Jr., R. C. Thomas.

WELTER, GUSTAVE, Vice-Pres., The Bigelow Co. PROPOSERS: Winfield Roeder, J. R. Smak. SECONDERS: A. J. Lawless, W. A. Johnson.

WILDER, FRANK B., Student, M.I.T. Graduate School. PROPOSERS: A. L. Hesselschwerdt, Jr., James Holt. SECONDERS: W. H. Jones, J. R. B. Mallik.

WILL, HAROLD C., Mgr., Air Cond. Div., J. A. Walsh & Co. PROPOSERS: J. A. Walsh, C. L. Boehler. SECONDERS: B. P. Fisher, D. M. Mills.

WOOD, FRED C., Mgr., Air Cond. Dept., York Corp. PROPOSERS: J. R. Hertzler, V. T. Kartorie. SECONDERS: E. R. Walsh, Jr., S. F. Nicoll. *(Advancement)*

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*Non-Member

CANDIDATES ELECTED

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

Members

ACKER, CHARLES B., Mech. Engr., U. S. Naval Air Station, Pensacola, Fla.

AKERMAN, JOSEPH R., Hd., Htg. & Air Cond. Dept., Milwaukee School of Engineering, Milwaukee, Wis. *(Advancement)*

ANDERSON, WILLIAM T., JR., Dir. of Research, Hanovia Chemical & Manufacturing Co., Newark, N. J.

BARFUS, LOUIS, Vice-Pres., Sarcotherm Controls Inc., New York, N. Y.

BECHIR, NICHOLAS V., Asst., Refrig. Dept., Volkart Brothers, Calcutta, India.

BERTRAND, GEORGE F., Sales Engr., Sheffler-Gross Co., Philadelphia, Pa. *(Advancement)*

BOVAY, HARRY E., JR., Cons. Engr., Houston, Texas.

BRINEN, HOWARD F., Research Engr., Young Radiator Co., Racine, Wis.

Brydia, Ellis M., Equip. Dvlpt. Engr., York Corp., York, Pa.

Connell, Lloyd L., Tech. Dir., Stoker Manufacturers Assn., Chicago, Ill.

Conway, Richard W., Sales Engr., The H. B. Smith Co., Inc., New York, N. Y.

Frambach, Frederick S., Engr., The Bahnson Co., Winston-Salem, N. C.

Garrard, Walter M., Garrard, Sudderth & Seat, Atlanta, Ga. *(Reinstatement)*

Graham, William F., Engrg. Dept., Imperial Iron Corp., Ltd., Toronto, Ont., Canada.

Grimm, J. M., Mgr., Crane Co., Columbus, Ohio.

Harris, Harold R., Sales Engr., H. R. Harris Co., Minneapolis, Minn.

Heitman, Joseph G., Chief Engr., R. B. Hayward Co., Chicago, Ill.

Hickox, Malcolm, Air Cond. Engr., G. C. Murphy Co., McKeesport, Pa.

Hofmeister, Harold J., Engr., Columbus Air Conditioning Corp., Columbus, Ohio.

Hosman, Paul S., Sales Engr., Mechanical Heat & Cold, Inc., Detroit, Mich.

Jones, Sidney J., Mgr., Thermotank Ltd., Middlesex, England.

Jordan, Frank W., Mgr., Air Cond. Div., Westinghouse Electric Corp., Los Angeles, Calif.

Kern, Charles J., Mgr., Control Engrg. & Service, Warren Webster & Co., Camden, N. J.

Kincaide, M. C. Detroit, Mich. *(Reinstatement)*

Kitchen, Francis A., Pres., American Warming & Ventilating Co., Cleveland, Ohio. *(Advancement)*

Lambert, Thomas A., Norfolk Naval Shipyard, Portsmouth, Va.

Lees, W. D., Edmonton, Alta., Canada. *(Reinstatement)*

Lorenzi, Robert J., Research Engr., John B. Pierce Laboratory of Hygiene, New Haven, Conn.

Lyon, James P., Sales Repr., Thatcher Furnace Co., Garwood, N. J.

McArdle, Francis E., Sr., Engr., Reconstruction Finance Corp., Washintgon, D. C.

Mills, Doremus L., Dvlpt. Engr., Revere Copper & Brass, Inc., Rome, N. Y. *(Advancement)*

Murphy, Tom O., Gen. Supt. & Pres., The T. O. Murphy Co., Oberlin, Ohio.

Reilly, B. B., Engr., Dravo Corp., Pittsburgh, Pa.

Rush, Merle K., Sales Engr., Hucker Sales Co., Philadelphia, Pa.

Shuster, Wilbur W., Cons. Engr., Wm. E. Bodenstein & W. W. Shuster, Cincinnati, Ohio.

Signor, Carl W., Engr., The Detroit Edison Co., Detroit, Mich.

Snow, David, Engr., David Snow Co., New York, N. Y.

Stokes, Thomas A., Air Cond. Engr., Mehring & Hanson Co., Washington, D. C. *(Reinstatement & Advancement)*

Streeter, Victor L., Civil & Mech. Engr., Armour Research Foundation, Chicago, Ill.

Associate Members

Allen, Roy H., Owner, Allen Copper Coil Co., Seattle, Wash.

Baghi, A. R. M., Service Engr., Anglo-Iranian Oil Co., Ltd., Abadan, South Iran.

Baker, Russell A., Branch Mgr., Minneapolis-Honeywell Regulator Co., Syracuse, N. Y.

Burnham, Harold T., Owner, Zanesville, Ohio.

Davis, Wilson L., Sales Engr., American Blower Corp., South Bend, Ind.

Doherty, Raymond S., Sales Mgr., Taco Heaters Inc., New York, N. Y.

Eck, Melvin C., Sales Engr., Bryant Heater Co., Cleveland, Ohio.

Edelman, Herbert W., Mgr., Purchasing Dept., Baker Manufacturing Co., Omaha, Nebr.

Emmett, James, Jr., Gen. Sales Mgr., James P. Marsh Corp., Chicago, Ill.

Fairclough, Roy J., Mgr., Htg. Dept., Crane Co., Salt Lake City, Utah.

Ferguson, Wallace N., Canadian Industries Ltd., Montreal, Que., Canada.

Fitzsimons, Robert H., Dist. Mgr., Trane Co. of Canada, Ltd., Toronto, Ont., Canada.

Godfrey, George A., Sales Engr., The A. R. Williams Machinery Co., Vancouver, B. C., Canada.

Goepper, Forrest S., Mech. Designer, Malcolm B. Nicholls, Cincinnati, Ohio.

Greatorex, John E., Htg. & Vent. Engr., Ministry of Fuel & Power, London, England.

Grimmer, Richard A., Designer of Air Cond., Htg., Vent. Equip., Fort Worth, Texas.

Hayes, William G., Owner, Hayes Distributing Co., Portsmouth, Va.

Hellekson, Owen H., Sales Engr., Minneapolis-Honeywell Regulator Co., Hartford, Conn.

Hiratsuka, Shigeki, Designer & Draftsman, Meyer, Strong & Jones, Inc., New York, N. Y.

Hopkins, Rodney, Engr., Marathon Paper Mills of Canada, Toronto, Ont., Canada.

Hurst, Floyd G., Design Engr., P. C. Hartman Co., Norfolk, Va.

Hutchinson, Ira B., Sales Engr., Frank Prox Co., Columbus, Ohio.

Lovenberg, Albert M., Application Engr., Consolidated Engineers, Inc., Springfield, Mass.

Lytle, William T., Hercules Powder Co., Lawrence, Kans.

MacKay, Harold J., Field Engr., Surface Combustion Corp., New York, N. Y.

Major, Leonard F., Partner, Major Heating Co., Detroit, Mich.

Mandt, Robert D., Research Asst., Case School of Applied Science, Cleveland, Ohio.

Marshall, James W., Engr., Natkin & Co., Houston, Texas.

Mead, Desmond O., Owner, George E. Mead Co., Seattle, Wash.

Murray, George F., Htg. Inspector, City of Hartford, Hartford, Conn.

Parsons, Leonard D., Jr., Passman Equipment Co., Monroe, La. *(Reinstatement)*

Patrick, Arthur L., Htg. & Plbg. Contr., Auburn, N. Y.

Perry, Charles E., Mgr. & Sales Engr., B. F. Sturtevant Co., Kansas City, Mo.

Peters, Charles J., Pres., Building Service Co., Inc., Baltimore, Md.

Pinter, Joseph L., Industrial Instruments, Inc., Jersey City, N. J. *(Reinstatement)*

Ralston, Ernest E., Partner, D. M. Allen Co., Kansas City, Mo.

Reynolds, Clifford M., Shop Foreman, Mountain Fuel Supply Co., Salt Lake City, Utah.

Seelbach, William R., Bryant-Seelbach Co., Buffalo, N. Y. *(Reinstatement)*

Shaver, Charles W., Jr., Assoc., Charles W. Shaver, Architects, Salina, Kans.

Smith, Harley H., Mgr., Govt. Dept., United States Radiator Corp., Washington, D. C.

Smith, Owen J., Assoc., Verne Simmonds Co., Omaha, Nebr. *(Reinstatement)*

Stephenson, James H., Sales Engr., Johnson Service Co., Milwaukee, Wis.

Stotz, Robert B., Marietta, Ga. *(Reinstatement)*

Tait, Andrew, Darling Brothers Ltd., Toronto, Ont., Canada.

Tarak, Harac H., Engr., Roberto Zander, Buenos Aires, Argentina, S. A.

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Massachusetts: Organized, 1912. Headquarters, Boston, Mass. Meets, Third Tuesday. President. D. M. Archer, 143 Federal St., Boston 10. Secretary, A. Ehrenzeller, 23 Parklawn Rd., Boston 32.

Memphis: Organized, 1944. Headquarters, Memphis, Tenn. Meets, First Monday. President, T. J. O'Brien, 1030 Exchange Bldg., Memphis. Secretary, A. T. Bevil, 1521 Waverly Ave., Memphis 6.

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Minnesota: Organized. 1918. Headquarters, Minneapolis, Minn. Meets, First Monday. President, R. E. Gorgen, 2120 W. Cedar Lake Blvd. Secretary, O. L. Lilja, 5000 16th Ave. S., Minneapolis 7.

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Ontario: Organized, 1922. Headquarters, Toronto, Ont. Meets, First Monday. Acting President, V. J. Jenkinson, 117 Peter St., Toronto 2B. Secretary, H. R. Roth, 57 Bloor St., W., Toronto, Ont.

Oregon: Organized, 1939. Headquarters, Portland, Ore. Meets, Thursday after First Tuesday. President, F. F. Urban, 6726 S. W. Burlingame Ave., Portland. Secretary, E. R. Lokey, 1238 N. W. Glisan St., Portland 9.

Pacific Northwest: Organized, 1928. Headquarters, Seattle, Wash. Meets, Second Tuesday. President, D. C. Griffin, 717 Lloyd Bldg., Seattle 1. Secretary, C. W. Finn, 702 Lloyd Bldg., Seattle 1.

Philadelphia: Organized, 1916. Headquarters, Philadelphia, Pa. Meets, Second Thursday. President, R. D. Touton, Ninth & Columbia Ave., Philadelphia. Secretary, F. H. Buzzard, 213 S. Broad St., Philadelphia 7.

Pittsburgh: Organized, 1919. Headquarters, Pittsburgh, Pa. Meets, Second Monday. President, L. S. Maehling, 778 Country Club Dr., Pittsburgh 16. Secretary, E. H. Riesmeyer, Jr., 231-33 Water St., Pittsburgh 22.

Rocky Mountain: Organized, 1944. Headquarters, Denver, Colo. Meets, First Wednesday. President, F. L. Adams, P.O. Box 840, Denver 1. Secretary, J. J. Johnson, 1010-17th St., Denver 2.

St. Louis: Organized, 1918. Headquarters, St. Louis, Mo. Meets, First Tuesday. President, W. J. Oonk, 4548 Red Bud Ave., St. Louis 15. Secretary, W. A. Russell, 7918 Kingsbury Blvd., Clayton 5, Mo.

South Texas: Organized, 1938. Headquarters, Houston, Tex. Meets, Third Friday. President, J. A. Walsh, P. O. Box 1773, Houston. Secretary, D. M. Mills, Gray & Crawford, Houston 3.

Southern California: Organized, 1930. Headquarters, Los Angeles, Calif. Meets, Second Wednesday. President, Maron Kennedy, 5051 Santa Fe Ave., Los Angeles 11. Secretary, R. A. Lowe, 3744 Potomac Ave., Los Angeles 16.

Utah: Organized, 1944. Headquarters, Salt Lake City, Utah. Meets, First Wednesday. President, H. G. Richardson, 1433 Harvard Ave., Salt Lake City. Secretary, E. V. Gritton, 2470 S. 15th East St., Salt Lake City.

Washington, D. C.: Organized, 1935. Headquarters, Washington, D. C. Meets, Second Wednesday. President, W. H. Littleford. 616 New York Ave., N. W. Secretary, J. N. Stewart, 6124-32nd Pl., N. W., Washington 15, D. C.

Western Michigan: Organized, 1931. Headquarters, Grand Rapids, Mich. Meets. Second Monday. President, H. J. Metzger, 137 E. Water St. Kalamazoo. Secretary, H. W. Wolters, 820 Staples Ave., N. W., Kalamazoo 54.

Western New York: Organized, 1919. Headquarters, Buffalo, N. Y. Meets, Second Monday President, F. A. Moesel, 31 Main St., Buffalo 3. Secretary, E. P. Heckel, Jr., 490 Broadway, Buffalo 4.

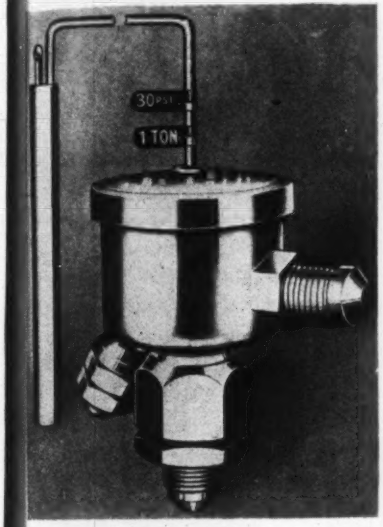
Wisconsin: Organized. 1922. Headquarters, Milwaukee, Wis. Meets, Third Monday. President, E. W. Gifford, 611 N. Broadway, Milwaukee 2. Secretary, B. M. Kluge, 1236 So. 46th St., Milwaukee 14.

EQUIPMENT DEVELOPMENTS

For your convenience in obtaining more information about any of this equipment, see coupon on this page. Add the new products and companies listed here to your Directory Section which you received in your January 1946 Heating, Piping & Air Conditioning and thus keep your records of sources of supply up to date throughout the year. Single asterisk indicates equipment not listed in Directory Section; double asterisk equipment and manufacturer not listed.

Thermostatic Expansion Valve Limits Pressure

No. 3107—The "Thermo-Limit," an automatic expansion valve for refrigeration systems which is designed to automatically limit evaporator or suction pressure, has been announced by Alco Valve Co., 865 Kingsland Ave., St. Louis 5, Mo.



Made at present to apply in the field of smaller commercial refrigeration, the device is said to eliminate heavy overload on the motor during the starting or pull-down period. In addition to the reduction of general strain and wear on the system, and less likelihood of burned out motors, in many cases smaller condensing equipment can be installed, says the manufacturer.

A small cartridge assembly consisting of a pressure-charged bellows, a valve push pin, and a spring partially take the place of the cage assembly in the more conventional valve. Excessive pressure built up in the low side of the system during the off cycle reacts on the cartridge bellows closing the valve when the predetermined evaporator pressure is reached. When the compressor starts, the valve remains closed until the evaporator pressure is reduced below the valve setting. As the pressure is further reduced, the valve begins to open and gradually shifts from pressure control to the normal function of superheat control.

Continuous Viscosimeter

No. 3108*—A continuous viscosimeter, whose operational characteristics are said to represent a radical departure from the usual method of viscosity measurement, has been announced by Fischer & Porter Co., 7346 County Line Rd., Hatboro, Pa.

Instantaneous observations of viscosity values existing in a moving fluid stream under full line pressure may be made. The device is available for simple indicating, may be arranged for continuous recording on a 24 hr chart, or may be used to control fluid viscosity by means of automatic blending or heating. It is said to be particularly valuable for blending lubricating oils and in the maintenance of constant fuel oil viscosity for improved oil burner operation.

Basically the device is an adaptation of the flow rate measurement method, in which fluid passes vertically upward in a conically tapered tube past a metering float, used in the company's line of "Rotameters."

Wrought Iron Pipe Used in Railway Switch De-Icer

No. 3109—The successful use of wrought iron pipe, containing an electrical heating element, to prevent track switches from freezing, has been reported by the A. M. Byers Co., Clark Bldg., Pittsburgh 22, Pa.

About 100 of these units, developed by engineers of the Cleveland Railway Co., were used successfully during the last winter. The heating element, designed for 2000 watts, 600 volts, uses the same power that is used to operate the transit system. It is encased in a 1½ in. wrought iron pipe approximately 11 ft in length. The unit runs parallel to the full length of the switch, buried about a foot deep. Operating somewhat on the principle of radiant heat, the de-icer warms the area surrounding the switch so that snow is melted and ice is prevented from forming.

New Thermostat Announced

No. 3110—A new automatic thermostat, making use of many war-born developments, has been announced by Minneapolis-Honeywell Regulator Co., 2604 4th Ave., S., Minneapolis 8, Minn.

Taking only the name "Chronotherm" from its prewar predecessor, the instrument is the result of years of research and will supplant all prewar models. Not scheduled for production until early 1947 because of current material shortages and the urgent demand for the company's standard products now in production,

Heating, Piping & Air Conditioning, [5-46]
6 N. Michigan Ave., Chicago 2, Ill.

Please ask the manufacturers to send me more information about the equipment mentioned under the following reference numbers in Equipment Developments and Recent Trade Literature.

(Circle each number in which you are interested)

3107	3108	3109	3110	3111	3112	3113	3114	3115	3116
3117	3118	3119	3120	3121	3122	3123	3124	3125	3126
3127	3128	3129	3130	3131					
6150	6151	6152	6153	6154	6155	6156	6157	6158	6159
6160	6161	6162	6163	6164	6165	6166	6167	6168	6169
6170	6171	6172	6173	6174	6175	6176	6177	6178	6179
6180									

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AMERICAN DISTRICT STEAM CO.
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the instrument nevertheless has been test-proven to offer many advantages never before available, says the manufacturer.

Time settings for day and night temperatures are set on a new quarter-hour interval scale. A new type bimetal element developed for the instrument is designed to assure accurate temperature control, and an additional electrical mechanism is incorporated to prevent overshooting the day time temperature setting during the morning pickup. The clock is of the self-starting type, employing a low speed motor to eliminate noise and can be adjusted by means of an external fingertip wheel. It is of the full face type for easy reading. A locking cover is also available.

Leak Detector for High Vacuum Systems

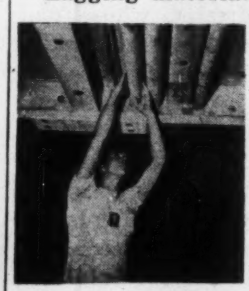
No. 3111—For indicating and locating minute leaks in high vacuum systems, the Westinghouse Electric Corp., has developed an electronic detector which is said to be capable of indicating the presence of contaminating substances in proportions as small as one part in several thousand.

The device is a special application of the mass spectrometer, an electronic instrument that weighs and sorts out individual molecules of different gases. This is accomplished by giving the molecules an electrical charge and then shooting them at high speed down a curved tube. Along the sides of the tube are electromagnets which guide the molecules so that only those of a particular mass, or weight, are passed through an exit slit and are counted on a special recorder. The presence of a known gas can thus be determined, and for leak detection with this instrument, helium is used.

To test a vacuum system, the unit is attached to it and pumps are started to evacuate the air in the system. A thin jet of helium gas is sprayed against each suspected location, or over the entire system. If there is no leak, the detector shows no reading, for normally there is no appreciable amount of helium in the atmosphere, and hence there are no molecules of the proper mass to actuate the recorder. Should the detector show a reading when the helium nozzle is held at a certain location, the operator knows that helium is entering the system at that point.

Lagging Cement

No. 3112—A quick drying lagging cement, used extensively during the war on many marine applications, was developed by the Arabol Mfg. Co., 110 E. 42nd St., New York 17, N. Y.**



Lagging materials, such as canvas, are submerged in this cement and in a few moments become saturated. The material is then partially wrung out and is wrapped around piping, ducts, etc. After wrapping, the material is smoothed out. While drying it contracts and pulls itself around the covering.

Application of this material is said to eliminate one coat of paint as it acts as a sizing and, according to the manufacturer, provides a smooth, fire retardant surface

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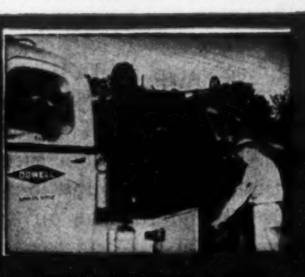

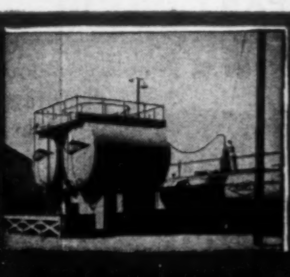

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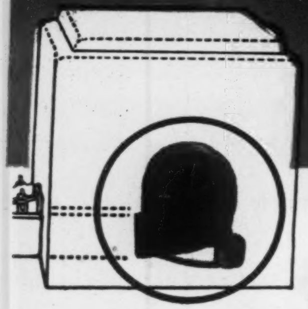

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ARE ODIOUS
....BUT NECESSARY

The mechanical features of an automatic coal stoker can make a great difference to a dealer or distributor, since they have a direct bearing on the profit he makes per dollar and per hour invested in the stoker business.

There *is* a difference in stokers, and the best way to find out is to make comparisons. We'll be glad to show you what the Link-Belt Stokers have on the ball, and how and why they are different. The Link-Belt line includes bituminous and anthracite hopper and bin-fed domestic models, and commercial and industrial stokers up to 1200 lbs. per hour coal feed capacity. Write for our proposition:

LINK-BELT COMPANY 10,267
Stoker Division
2410 W. 18th St. Chicago 8, Illinois

LINK-BELT
Magic Flame and Power-Flex
STOKERS

which takes paint readily. Oil accidentally spilled on the surface is wiped off with waste, leaving a clean finish. It is suitable for brushing or spraying on glass cloth and other insulation materials.

Electric Hygrometer for Precision Measurement and Control of Humidity

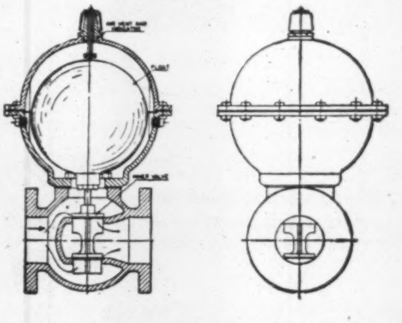
No. 3113*—The "Aminco-Dunmore" electric hygrometer for high precision humidity measurement and control has been announced by the American Instrument Co. of Silver Spring, Md.

It has been successfully applied to measurement of humidity within ordnance water vapor barriers of several sizes and types, measurement of soil moisture content, studies of moisture in concrete, and water vapor permeability studies. This new instrument employs a sensing element that is claimed to be the speediest device known for measuring humidity changes, and which is compact, precise, and instantly responsive to microchanges in relative humidity. The unit is said to give reproducible readings throughout the entire standard dry bulb temperature range of 40 to 120 F, and relative humidity range of 7 to 100 per cent. Microchanges within plus-minus 0.5 per cent relative humidity are sensed, indicated, or recorded within the standard temperature range. The instrument is said to be exactingly precise, even for moisture determination at low relative humidity.

Automatic Shutoff Valve

No. 3114—The "Air-Lok" valve, announced by the Davis Regulator Co., 2546 S. Washtenaw, Chicago 8, Ill., is designed to automatically close when the withdrawal or transferring of liquid is completed and before any air or vapor enters the system.

The device is offered primarily for use on gathering lines connected to oil field lease tanks; however, since this design combines most of the features of a conventional float box, balanced valve hookup, the manufacturer considers that it is suitable for other applications in industry, such as for draining condensate chambers of multiple effect evaporators, gas liquid accumulating tanks, and steam condensate flash tanks.



A shown in the accompanying illustration, the unit consists of a spherical float connected to a balanced double disc valve. With liquid available in the gathering line, the level rises in the float chamber and causes the valve to open. Threaded connections are provided in the float chamber for the installation of equalizing lines where found desirable. At present the valve is offered for use on 3 or 4 in. lines, for pressures up to 150 psi, and for temperatures up to 250 F.

for **PEAK PERFORMANCE** *on all*

Comfort Cooling Installations

specify

SPORLAN

"G" charge

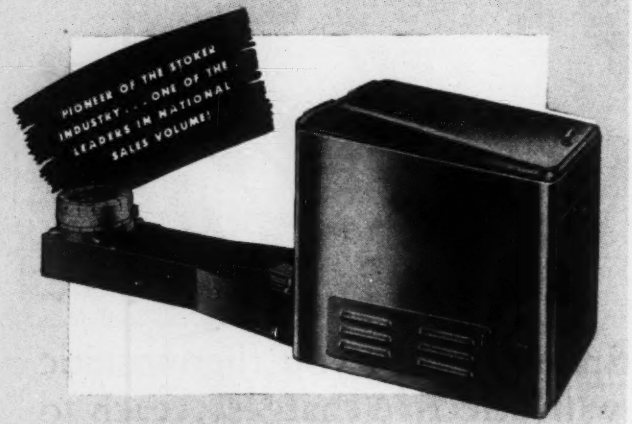
Only Sporlan offers you thermostatic expansion valves with selective charges . . . each to do a specific job. So don't just ask your wholesaler for a valve . . . ask him for a Sporlan valve, selectively charged to give you peak performance on any size installation.

SPORLAN

Specify Sporlan throughout

when ordering strainers, solenoid valves, thermostatic expansion valves or refrigerant distributors, and you'll get an unbeatable combination of perfect performers!

SPORLAN
VALVE COMPANY
3723 Commonwealth Ave.
ST. LOUIS 17, MISSOURI


PIONEER OF THE STOKER INDUSTRY . . . ONE OF THE LEADERS IN NATIONAL SALES VOLUME!

6 REASONS

WHY YOU'LL PREFER

FREEMAN LONG-LIFE STOKERS

FIRST CHOICE OF AMERICA'S FOREMOST HEATING ENGINEERS

1 A COMPLETE LINE

2 YEARS OF EXPERIENCE

3 PERSONAL COOPERATION

4 ENGINEERING LEADERSHIP

5 FINANCIAL STRENGTH

6 AGGRESSIVE PROMOTION

FREEMAN STOKER DIVISION
ILLINOIS IRON & BOLT CO.
918 S. MICHIGAN AVE., CHICAGO 5, ILLINOIS

Honeywell Purchases New Toronto Factory

No. 3115—Purchase of a new plant which will triple Canadian manufacturing facilities has been announced by H. W. Sweatt, president of Minneapolis-Honeywell Regulator Co., 2604 4th Ave., S, Minneapolis 8, Minn.

Located at Leaside on the outskirts of Toronto, the new factory, which was purchased from Small Electric Motors (Canada) Ltd., already is in production and currently is employing 250 persons on the manufacturing and assembly lines.

Built at the beginning of the war for the production of gunsights and other fire control instruments for the Canadian, British and American navies, the plant was purchased complete with machine tools which, Mr. Sweatt said, are ideally suited for the manufacture of the company's line of heating, ventilating and air conditioning control instruments.

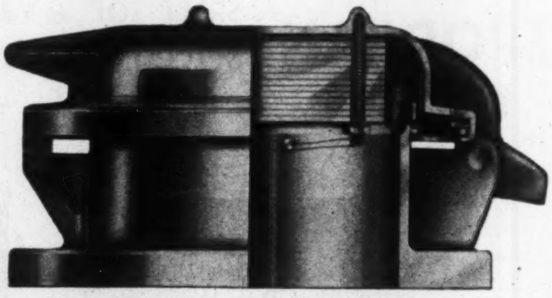
Under direction of W. H. Evans, general manager for Canadian operations, the new plant will make and assemble the major share of all of the company's controls for the Canadian market.

Manufacturing and sales operations formerly located at the company's older facilities at 117 Peter Street, Toronto, were terminated at the end of March and the transfer to the Leaside location fully completed.

Pressure-Vacuum Vent Valve

No. 3116*—Now in production at Black-Sivalls & Bryson, Inc., 7501 E. 10th St., Kansas City 3, Mo., is a line of pressure-vacuum vent valves.

A cast iron body and a cast aluminum cover are so arranged that normal pressure within the valve seats a flexible neoprene or synthetic rubber gasket on the rim of the body. The greater the pressure the tighter the valve holds until over pressure lifts the hinged cover. If a vacuum develops, atmospheric pressure lifts the valve gasket.



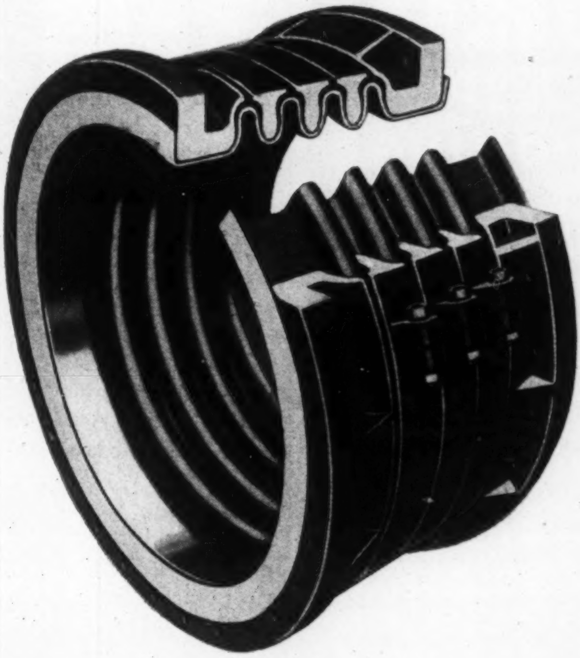
Valve sizes from 2 to 24 in. are available with base flange 150 ASA bolting pattern. Standard opening pressures vary with different sizes and range from 1½ to 3 oz. Maximum opening pressures range from 4 to 16 oz and the standard opening vacuum is ½ oz.

Integral Grinding Dust Collector

No. 3117—For the collection of grinding dust, the Aerotec Co., White Plains, N. Y., has introduced a unit, consisting of collector and high static pressure fan, which is designed for close coupling to a hood.

Dust laden air enters at *A*, and coarse material is

*Train up a child in the way he should go;
and when he is old he will not depart from it.*
—PROVERB



Direct the flexing of a corrugated expansion joint in the way it should go; and even when it is old it will not depart from it.

If it's Badger made it's got something

BADGER Self-equalizing Corrugated Expansion Joints are the only joints for high-temperature and high-pressure lines in which the flexing movement and stresses are definitely directed in such a way that:

> *All the corrugations share the stress load equally; All points of the surface of each corrugation share its individual load equally.*

Badger ALL-CURVE Directed Flexing Rings and Badger ALL-CURVE corrugations are the combination that does the job. Excessive stresses can't pile up locally in pockets, corners or junctions. Nor unevenly among the corrugations. They can't "blow the joint"—endanger the line or shorten the life of these superbly engineered joints.

Special Badger methods of forming the corrugations from a single piece of tubing contribute further to the strength of these joints; and a special Badger heat treatment preserves their flexing qualities.

Each corrugation affords a definite standard of traverse, according to its depth and the diameter of the joint. This makes it easy to determine the number of corrugations needed to absorb the maximum longitudinal expansion of any length of line.

Once you've installed dependable, long-lasting Badger Corrugated Joints with DIRECTED FLEXING Rings, your pipe-expansion problems are solved for the life of the line.

MADE IN COPPER, STAINLESS STEEL AND OTHER ALLOYS—Copper for normal pressures and temperatures; Stainless Steel and other alloys for higher requirements—and where corrosion is a problem. Single or multiple corrugations—for traverses from a fraction of an inch upward. Also made in Non-equalizing type (without rings) for uses that do not require added protection. SEND FOR BULLETIN NO. 100 (*Self-equalizing*) or No. 200 (*Non-equalizing*).

E. B. BADGER & SONS CO., 75 Pitts Street, Boston 14, Mass.
AGENTS IN PRINCIPAL CITIES

Badger

PACKLESS CORRUGATED EXPANSION JOINTS

McCORD HEATING AND AIR CONDITIONING PRODUCTS

BLAST HEATING COILS—AIR CONDITIONING COILS—ALL TYPES

All copper spiral fin tube construction with the tubes formed or bent permits uniform expansion without strain. Headers are heavy wall construction with tubes brazed into extended ferrules formed in the headers. Fins are helically wound and metallically bonded. May we send catalog?

VERTICAL TYPE UNIT HEATERS

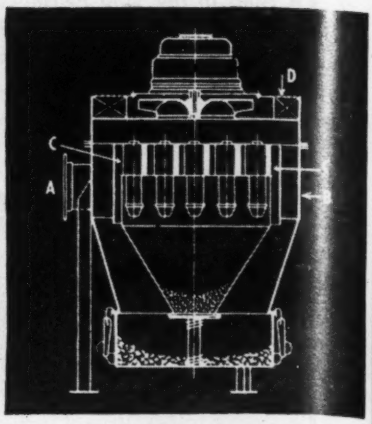
A proven heating unit, modern in design, incorporating every unit heater advancement. McCord copper spiral fin tube construction creates air turbulence without undue restriction. Improved fan blades deliver large volume of air with minimum air noise. Guaranteed for 150 lbs. saturated steam pressure. Specify McCord.

HORIZONTAL TYPE UNIT HEATERS

A time proven heating unit, modern streamlined in design, quiet, yet its rugged construction adapts it to all types of installations, guaranteed for use on No. 150 p.s.i. steam pressure. All copper heating element, individual spiral fin tubes free to expand without strain on joints. Standard motors with standard bases used. Wide range of capacities.

Save fuel with McCord Unit Heaters.

McCord CORPORATION
DETROIT 11, MICH.

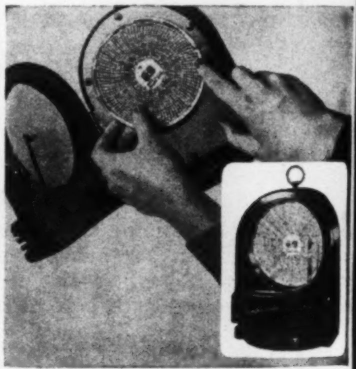


precipitated in the primary collector, *B*, as indicated in the accompanying sketch. Partially cleaned air enters the annular space, *C*, into the tube secondary, where fine dust is precipitated. Cleaned air is exhausted back into the room through annular space *D*. Though the device is applicable to most grinding dust collection problems, an electrical secondary collector, operating from a standard lighting circuit, may be obtained for those operations where extremely fine, non-explosive dust is encountered.

According to the manufacturer, a number of state hygiene and health departments have accepted this unit and negotiations are under way to obtain nation wide acceptance. Sales and project engineering are being handled by the Thermix Engineering Co., First National Bank Bldg., Greenwich, Conn.

Temperature and Operation Recorders

No. 3118—A new line of "Tempscribe" recorders for room and atmosphere temperature and for electrical operation has been developed by the Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Pa.



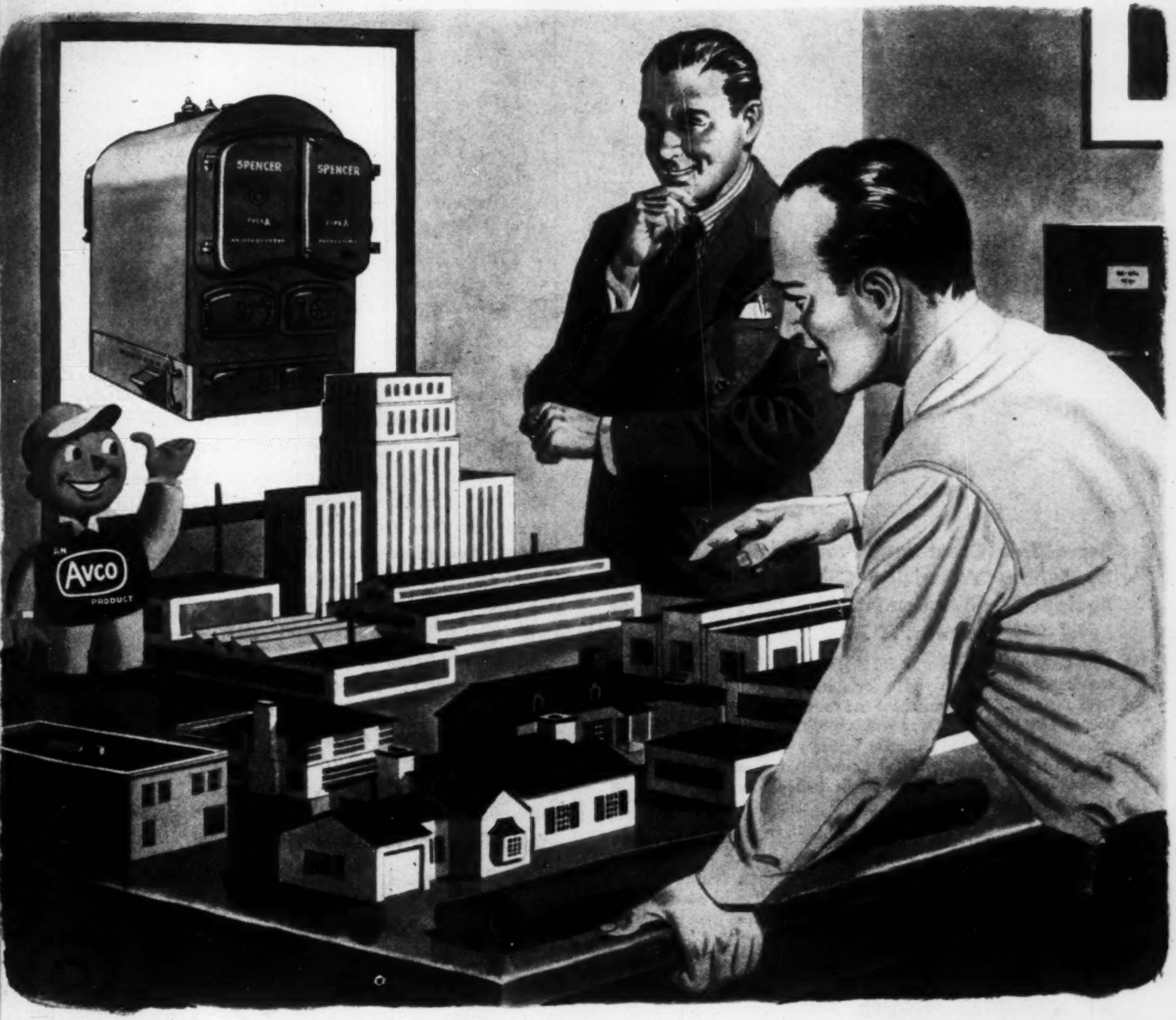
These recorders are designed primarily as portable field instruments for obtaining temperature and operation data on heating, space cooling, and air conditioning systems. In addition, the unit may be used for making a cyclic record of the flow of current through electrical devices such as motors, and the recorders are said to be suitable for permanent installation. Since the bi-metallic temperature element is located in the front door, changing charts and inking the pen is a simple matter. Moreover, by changing the hinged door of the instrument, the recorder can be converted for use in a different temperature range or as an operation recorder. Various combinations of time and temperature ranges from —10 to 130 F and for either 8 or 24 hr are available.

Electric Immersion Heater for Liquids

No. 3119—The American Instrument Co., Silver Spring, Md., is now offering a new automatically controlled, electric immersion heater for liquids.

Designed so as to be easily fitted to almost any tank

"Whether it's a Cape Cod or a Skyscraper
INSTALL A MODERN SPENCER"



Today's drafting boards are loaded with plans for new projects. Into these plans go the "last word" in postwar design and construction. A deserving compliment to modern engineering is a precision-built Spencer heating unit.

You can rely on a Spencer to do the job efficiently and economically. Since 1890, there's been no more dependable name in heating. Teamed with this time-tested *know-how* is the great technical experience and resources of The Aviation Corporation.

Whatever you may require in heating, there's a Spencer steel boiler to do your job efficiently. Spencer offers not one but all types, as shown in the catalog of our complete line. More than likely it has details of units you will want to include in the specifications of new construction you are planning. Write for a copy *now*.

SPENCER HEATER

**Division—The Aviation Corporation.
Dept. H-4, Williamsport, Pa.**

RETURNED VETERANS AND FAMILIES WANT ECONOMICAL SMALL HOME HEATING . . . WITH *Automatic Temperature Controls . . .*

Serve This Great and Profitable New Market By Selling Vaporizing Oil Burner Appliances Equipped with Dependable "A-P" Constant Level Oil Controls . . . . .

PERFORM a genuine service for the great army of returning service men eager to establish and enjoy modest, comfortable homes for their families. Tell them about the convenience, economy, and all-around efficiency of heating with vaporizing oil burner space heaters, floor furnaces, and basement furnaces equipped with a dependable "A-P" Constant Level Oil Control that assures uniform home heating automatically. You will be building customer good-will as well as profitable sales volume!

Leading makes of Vaporizing Oil Burner Appliances equip their units with the dependable, fuel-saving "A-P" Constant Level Oil Control. It is to your immediate and profitable advantage to feature this efficient equipment that affords smaller type homes such genuine heating comfort and economy.

WRITE for new illustrated Bulletin describing the "A-P" Constant Level Oil Control with "Magic Pilot."

Illustrated is the "A-P" Model 240 WYP Constant Level Oil Control for water heaters—equipped with "Magic Pilot." The "Magic Pilot" also is available on other model controls for vaporizing burner floor furnaces and furnaces, where a low pilot flame must be maintained indefinitely.

AUTOMATIC PRODUCTS COMPANY
2460 North 32nd Street, Milwaukee 10, Wisconsin

DEPENDABLE *Oil Controls*

A-P CONTROLS ARE DESIGNED TO ELIMINATE SERVICING!

or drum, the unit is said to be ideal for installation in domestic and industrial water tanks, drums, processing kettles, stills, sterilizers, crank cases, pipe lines, glue pots, etc. A built-in safety device is provided to limit the temperature rise and to protect the heater in the event of a very low liquid level. Two or more of these heaters may be installed on one application and may be arranged for step temperature control, or the safety heater may be used to regulate one or more non-automatic heaters through a relay. The temperature range is from room temperature to 350 F, and, according to the manufacturer, the thermostat will maintain the liquid temperature within 5 deg of a given setting. Heaters are available with copper sheathing for heating water or with steel sheathing for heating light oils, in four sizes—250, 500, 750, and 1000 watts.

Heating Equipment Manufacturer Expands

No. 3120—The National Radiator Co., 221 Central Ave., Johnstown, Pa., has purchased the Pullman-Standard Car Co. plant at Middletown, Pa., according to an announcement by R. S. Waters, president.

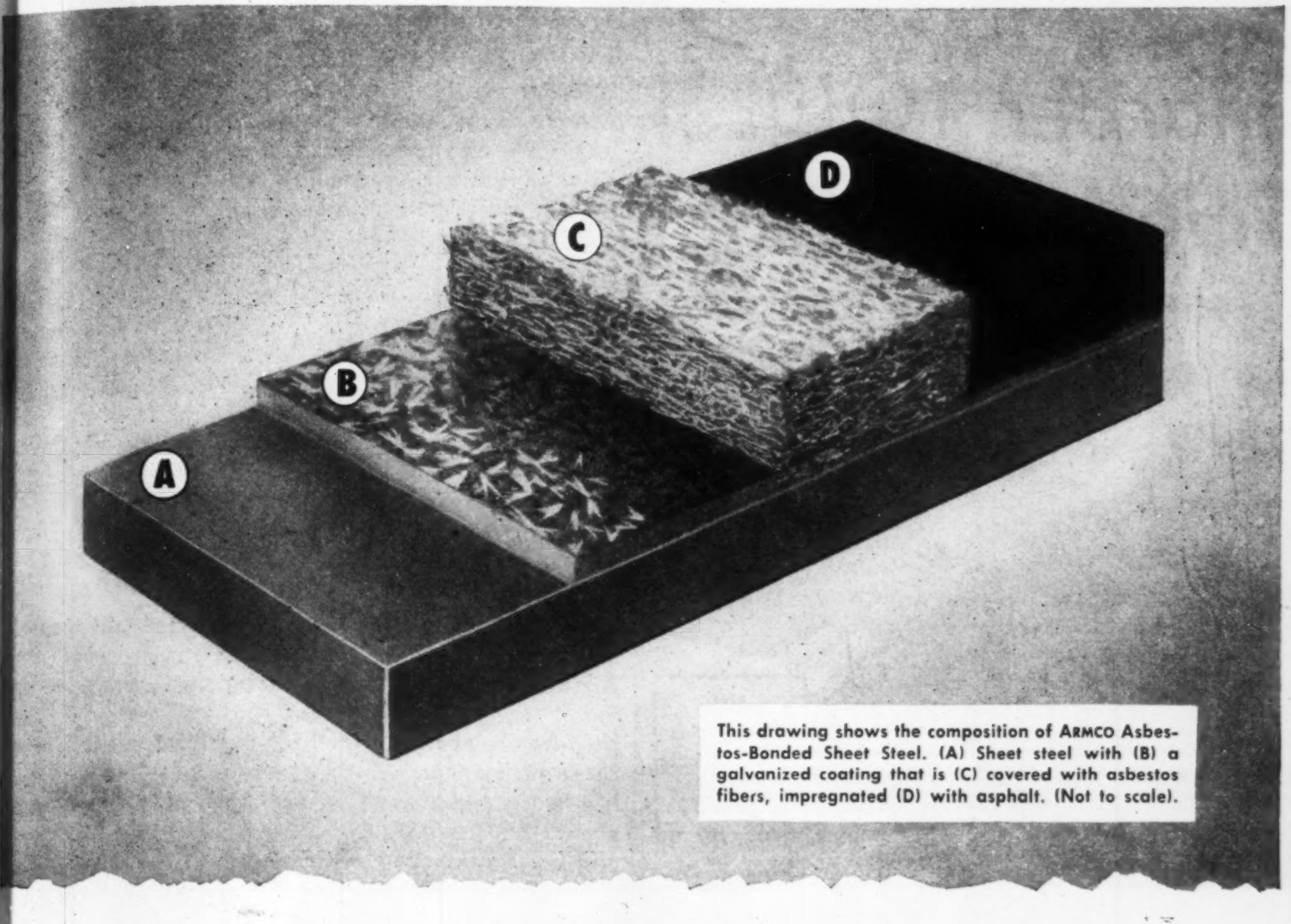
The plant will fabricate steel boilers for industrial and domestic purposes, pressure vessels, heat exchangers and other industrial products, formerly made at the firm's Lebanon plant. The company's other five plants are located at Johnstown and New Castle, Pa., and Trenton, N. J.

The Middletown property has upwards of 300,000 sq ft of floor area which will allow the company to increase its production of equipment used in the heating, chemical, petroleum and processing industries. The entire plant will not be put into operation at once due to needed reconversion. When working full capacity it will employ in the neighborhood of 1,500 people.

Coupling for Flexible Tubing

No. 3121*—A coupling designed for the company's line of flexible tubing is offered by the Warner Bros. Co., Spiratube Div., Bridgeport 2, Conn.

The coupling, which is built into the tubing, is designed to eliminate the need of fittings and to provide a simple, foolproof method of joining and disconnecting individual sections of the tubing. It consists of a flat spring steel collar which may be compressed to slip inside the end of another section and is then released to form a tight joint. Like the rest of the tubing, the couplings are covered with duck fabric which has been processed fire resistant and coated with a thermoplastic. Since no metal is exposed, it is said to be safe in the presence of explosive and inflammable materials and to eliminate sparking hazards.



This drawing shows the composition of ARMCO Asbestos-Bonded Sheet Steel. (A) Sheet steel with (B) a galvanized coating that is (C) covered with asbestos fibers, impregnated (D) with asphalt. (Not to scale).

HERE IS ASBESTOS-BONDED STEEL

FOR INDUSTRIAL VENTILATING USES

The newest special-purpose sheet steel for various kinds of industrial ventilating equipment is "ARMCO Asbestos-Bonded Steel."

It is the sheet steel counterpart of ARMCO Asbestos-Bonded Steel Pipe—used successfully for many years in better-grade road drainage structures. Now this coated steel is available in sheet form in 16-gage and heavier.

ARMCO Asbestos-Bonded has a coating of zinc with a layer of asbestos felt that is firmly pressed into the zinc coating while it is still molten. The asbestos felt layer is then impregnated with hot asphalt. The surface is relatively smooth and uniform and is off-black in color.

Resists Gases

Because it has exceptional resistance to acids and their gaseous compounds, ARMCO Asbestos-Bonded is ideal for industrial ventilating equipment. And it can well be used for "hidden" sheet steel air conditioning equipment that cannot be painted regularly—especially parts that are exposed to dampness or condensation.

You are invited to test ARMCO Asbestos-Bonded sheets. For samples and full information write The American Rolling Mill Company, 1291 Curtis Street, Middletown, Ohio.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION

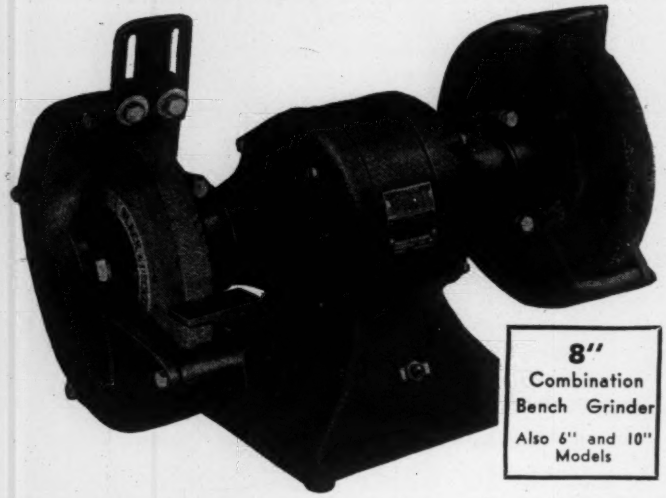
★ ARMCO ★

THE AMERICAN ROLLING MILL COMPANY

SPECIAL-PURPOSE SHEET STEELS

Sharper TOOLS! Smoother JOBS!

. . . with Black & Decker BENCH GRINDERS



8"
Combination
Bench Grinder
Also 6" and 10" Models

Black & Decker Bench Grinders keep a keen cutting edge on your tools—help you turn out cleaner work, faster. These Grinders handle many other jobs too! They grind pipe, rings, connections, fixtures, etc.—wire brush, buff, burnish, polish and finish sheet metal—remove weld marks and saw or shear burrs.

Long wheel spindles and tapered end housings make room for large or odd-shaped pieces. Powerful motors maintain high operating speeds under pressure—help you get work done sooner. Many other features.

Ask your Black & Decker Distributor about Black & Decker Bench Grinders and other Electric Tools for heating, piping and air-conditioning work. Or write to: The Black & Decker Mfg. Co., 628 Pennsylvania Ave., Towson 4, Maryland.

"WHIRLWIND"* WIRE BRUSHES

Perfect team-mates for Black & Decker Grinders. Tougher, denser, last longer . . . because each tuft is locked in place to stay. Six wheel sizes: 4" to 12". Three wire sizes. Three thicknesses. Fit almost any arbor or spindle.

*Trade-Mark Reg. U. S. Pat. Off.

LEADING DISTRIBUTORS EVERYWHERE SELL

Black & Decker

PORTABLE ELECTRIC **TOOLS**

DRILLS • HOLE SAWS • DRILL STANDS • PORTO-SHEARS
BENCH GRINDERS • SANDERS • PORTABLE GRINDERS

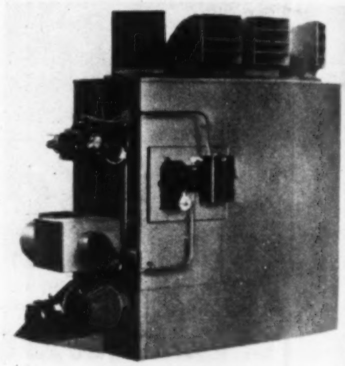
New Industrial Plastic

No. 3122—A new industrial plastic, known as "Teflon," has been announced by E. I. du Pont de Nemours & Co., Wilmington 98, Del.

This material, tetrafluoroethlene, was developed for special military uses during the war. Limited amounts in the form of sheets, rods, tubes, coated wire, tape, and fabricated sections are now available for experimental purposes. Among the characteristics of this product are high impact strength, toughness, a very low water absorbant rate, low dielectric loss factor, great chemical resistance, and the ability to withstand high temperatures. Various industrial uses for which this material is considered applicable include hydrochloric acid systems, pump gaskets, high temperature heating systems, distillation equipment for acids, and many kinds of insulation.

Direct Fired Space Heater

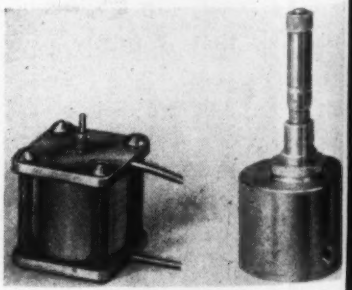
No. 3123—Self contained, direct fired air heaters, designed for burning either oil or gas are offered by Airtherm Mfg. Co., 711 S. Spring Ave., St. Louis 10, Mo.



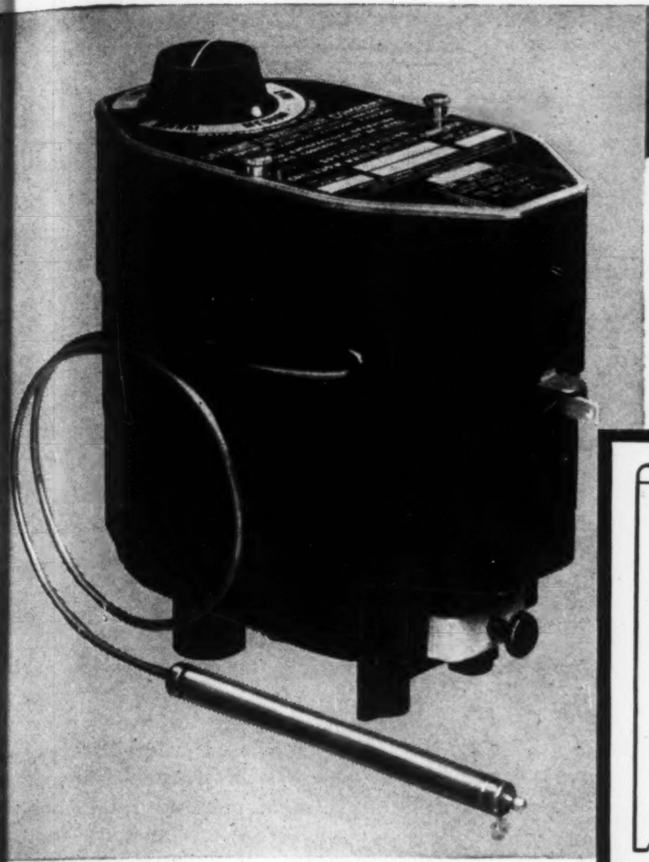
Units are available in three standard sizes, each in three models, namely floor mounted, vertical suspension, and horizontal suspension. Capacities range from 650,000 to 1,950,000 Btu per hr. Heaters are fully automatic and are furnished completely assembled, ready for connection to power and fuel supply and to the stack. Three double inlet, double width fans, directly driven and mounted on a common shaft, are located at the air inlet side of the heater. Air directional outlets are standard on all models and may be adjusted 360 deg. Units suitable for connection to distribution ducts are also available and filter boxes can be provided for special applications.

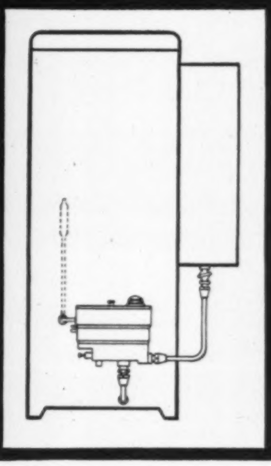
Precise Flow Control For Liquids and Gases

No. 3124—"Microl" valves, designed for precise control of liquid and gas flow, are offered by the Standard Instruments Co., 15 Elkins St., South Boston 27, Mass.**



The flow of air and other gases may be varied over the range of 0.2 to 60 cu in. per min with a pressure drop across the valve of 15 psi. Under the same conditions, the flow of water and other light liquids may be varied from 0.04





SELL
WATER HEATING
By Oil

good heaters are equipped WITH "Detroit" Float Valves

Actual tests show that the good oil fired water heater is ideal for satisfaction and economy. It will provide ample supplies of hot water at remarkably low fuel cost.

This makes a fine sales proposition—which is even better if the water heaters are equipped with "Detroit" Float Valves.

These valves automatically compensate for fuel flow variations due to oil temperature changes—may be adjusted to different grades of fuel—have hardened steel safety trip mechanism—are easily regulated by the user for desired water temperature.

The power element automatically regulates the burner to keep water hot. It is a "fail safe" element—in case of damaged element, the burner goes to low fire.

These valves are simple—have few parts—are easy to clean and service.

Look for "Detroit" Float Valves on the heater you sell—they are evidence of a quality product.

DETROIT LUBRICATOR COMPANY *General Offices:* 5900 TRUMBULL AVENUE
DETROIT 8, MICHIGAN

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

Canadian Representatives—RAILWAY AND ENGINEERING SPECIALTIES LIMITED, MONTREAL, TORONTO, WINNIPEG

"DETROIT"

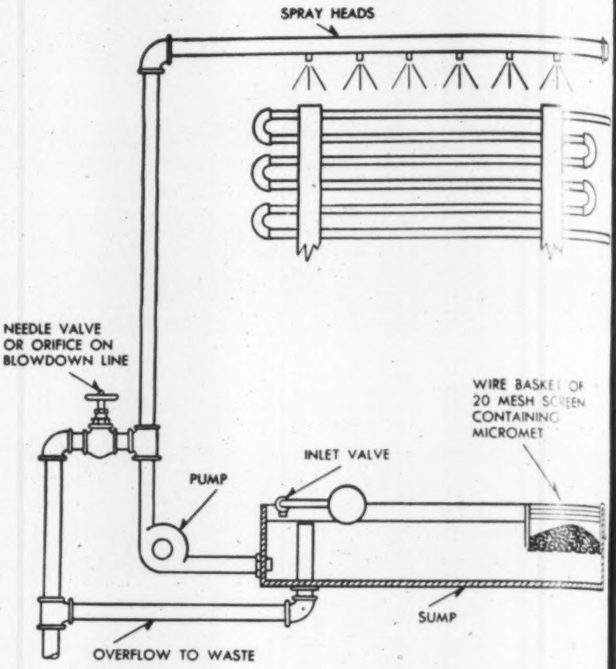
"Detroit" Heating and Refrigeration Controls • Engine Safety Controls • Safety Float Valves and Oil Burner Accessories • "Detroit" Expansion Valves and Refrigeration Accessories • Stationary and Locomotive Lubricators to 10 cc per min. Flow control is obtained by moving an adjustable plunger which varies the length of a capillary passage from 5 to 600 in.

Made of noncorrosive metals, the valves are designed to withstand vibration and mechanical abuse. A feature of the valve is the relatively large cross-sectional area of the capillary passage which is said to minimize the possibility of plugging. Shown here are two valves, the one on the right being a laboratory model with micrometer adjustment to demonstrate the principle of operation. The valve on the left is offered to equipment manufacturers who provide a mounting and means for either manual or automatic adjustment.

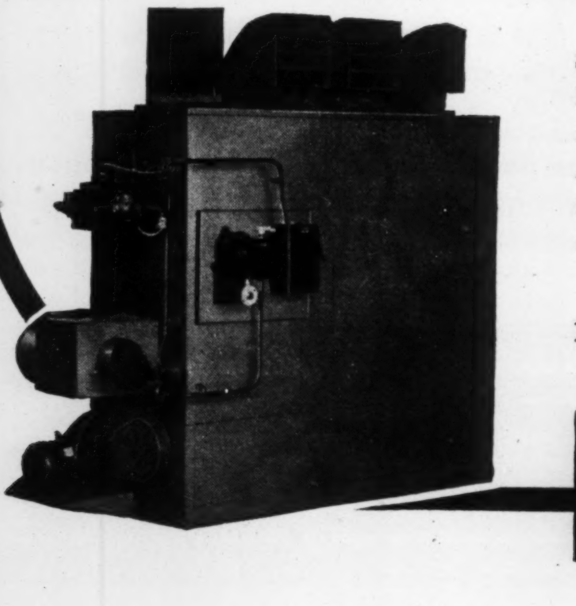
Prevention of Scale on Evaporative Coolers and Condensers

No. 3125—Widespread use of "Micromet" in industry for preventing the formation of lime scale on the tube surfaces of evaporative condensers and coolers has enabled Calgon, Inc., Hagan Bldg., Pittsburgh 30, Pa., to offer more detailed and comprehensive recommendations regarding the proper use of this material.

All waters are either soft and corrosive or hard and scale forming. The latter type, when passed over an evaporative condenser, is heated and tends to lay down a lime scale which becomes baked on the tubes. When the makeup water for the condenser is passed through this material, the dissolving of only about five parts per million parts of water is necessary to do the job. To obtain maximum benefits, the degree of hardness of the water must be taken into account.


SPRAY HEADS
NEEDLE VALVE OR ORIFICE ON BLOWDOWN LINE
WIRE BASKET OF 20 MESH SCREEN CONTAINING MICROMET
INLET VALVE
PUMP
SUMP
OVERFLOW TO WASTE

As the water is recirculated, the concentration of the scale forming salts is built up due to the evaporation. This concentration is controlled by overflowing to waste a calculated quantity of recirculated water and making up this loss with fresh water. The manufacturer has tabulated recommended quantities of waste water for various degrees of hardness and has also tabulated recommendations as to the amount of charge for this chemical in terms of refrigeration tonnage.



SIMPLIFIED CONSTRUCTION MEANS
LOWER OPERATING COSTS!

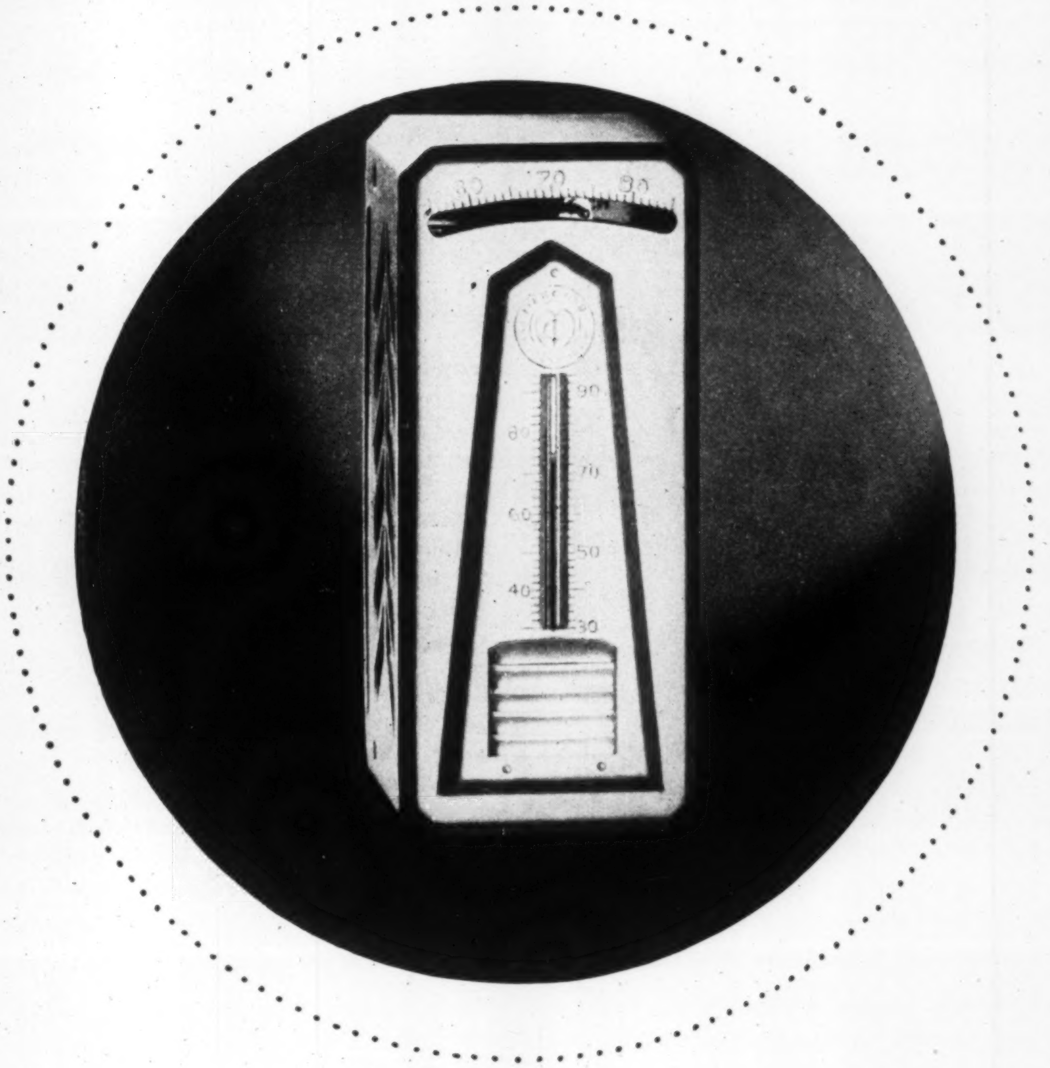
Airtherm Direct Fired . . .
Space Heater

Simplified construction of primary and secondary heating surfaces to accomplish low internal resistance was of prime importance in the design of the Airtherm Direct Fired Space Heater. The result is low power cost to you without the sacrifice of over-all efficiency.

Bulletin 801, describing this new Airtherm Heater in detail will be sent you on request.

AIRTHERM
MANUFACTURING COMPANY

711 S. Spring Avenue • St. Louis, Missouri



A Mercoid Product

The Mercoid Sensatherm is emerging in this post-war period unexcelled in its simple beauty, with its appealing lifetime lustrous natural metallic finish. There is no lacquer coating to become dull, nor can it ever tarnish. It holds its newness in appearance indefinitely. No polishing or scrubbing is ever necessary—simply wipe off any accumulated dust or dirt with a damp cloth, in fact a dry cloth usually does quite as well.

And speaking of performance, this instrument still remains unmatched for its even room temperature control. There are many factors in its design and construction contributing to its long life and positive operation, particularly the hermetically sealed mercury switch. Summing up its appearance and performance, the Mercoid Sensatherm is truly the aristocrat among thermostats—Manufactured by The Mercoid Corporation, Chicago 41

GENERAL CONTROLS

UNSURPASSED VALVES

K-10 SERIES

ELECTRO MAGNETIC LEVER VALVES

FOR CONTROLLING air, water, gas, steam, light and heavy oils, and refrigerants, etc. Suitable for pressures up to 1,000 pounds and temperatures up to 400°F.

Internal valve assembly can be removed for cleaning and inspection if necessary. Two-wire—A. C. or D. C.—current failure—packless construction—bronze body—stainless steel and bronze internal parts—soft seats available.

SIX TIMES THE POWER of ordinary solenoid valves. This feature assures high seating pressure and overcomes the effect of viscous fluids, such as heavy fuel oil. Adequate power of the solenoid insures positive operation. Available in normally closed or open types.

FOR COMPLETE SPECIFICATIONS on temperature, pressure and flow controls for industrial applications write for new 1946 Catalog 52C or contact Factory Branch or Distributor near you.

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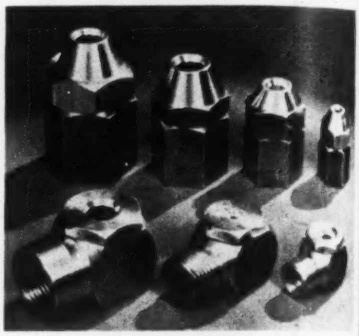
Improved Room Coolers To Be Available Soon

No. 3126—The Carrier Corp., 302 S. Geddes St., Syracuse 1, N. Y., has announced that the company's line of room coolers has been redesigned and will be available before mid-year.

These units, which have been off the market during the war, can be fitted into any window more than 26 in. wide and are designed to cool and ventilate rooms in homes, apartments, offices, etc. Larger floor model types will also be available.

Spray Nozzles

No. 3127—Various types of spray nozzles for water, oils, and other liquids are now being manufactured by the Delavan Engineering Co., Des Moines, Iowa.**



According to the manufacturer, these nozzles are suitable for many uses in air conditioning, air washing, humidifying, room cooling, and industrial processes. They may be readily taken apart for cleaning and are said to incorporate many non-clogging features. In addition to the regular line, special designs may be obtained by manufacturers who are confronted with unusual nozzle applications.

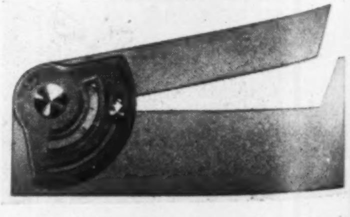
Research Department To Be Enlarged

No. 3128—York-Shipley, Inc., York, Pa., is planning to enlarge the facilities and activities of its research department.

This expansion is designed to provide the most advanced design and effective operation of the company's line of oil burning equipment and "Steam-Pak" generators. Ralph Gibbs, formerly chief chemist and consulting engineer for York Corp. and the author of many papers dealing with refractory problems, has been appointed director of research.

Drafting Tool

No. 3129—A new drafting tool, designated as the "S & J Quadrangle", has been announced by the Stewart-Jackson Instrument Co., 614 A. G. Bartlett Bldg., Los Angeles 14, Calif.**



The instrument has eight drawing edges, is rectangular in shape, and may be used as a triangle. In addition, angles from 0 to 90 deg., pitch scales from 0 to 24/12, percentage slopes from 0 to 100 per cent, sine and cosine functions, and tangents may be found. The overall size of this plastic instrument is 4 x 11 in.

DON'T LET DEMON HEAT HOLD DOWN YOUR PROFITS!

Unwanted heat reduces efficiency, cuts production, increases costs.

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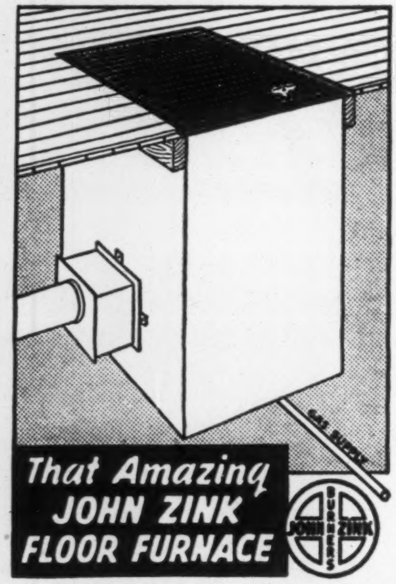

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As you would expect this Furnace features a larger, improved combustion chamber and a One-port Non-plugging Gas Burner.

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Development of New Heating and Air Conditioning Equipment Announced

No. 3130—During a recent company convention, the Trane Co., La Crosse, Wis., announced a number of product developments in heating and air conditioning equipment.

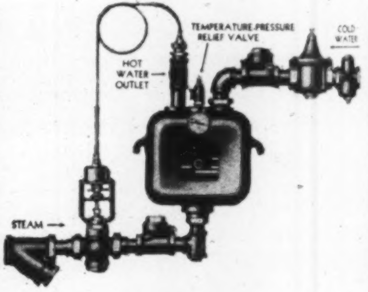
Among the new items is a convector-radiator with a heating element which is suitable for use with all standard steam and hot water heating systems. The unit will be made in a single cabinet model which can be installed either as a free standing or semi-recessed unit. According to the manufacturer, it will be carried extensively in warehouse stocks "and will be available on the spot for even the smallest job."

Another new development is the "Custom-Air" system of air conditioning. Designed for large, multi-roomed, multi-storied buildings, the new system is said to combine a number of the company's products in a system which develops maximum conditions of comfort. A new line of "Climate Changer" air conditioning units was also announced, in addition to improved evaporative condensers, reciprocating compressors, railway air conditioning units, wall fin heaters for industrial use, a dry expansion chiller, several new types of heat transfer surfaces for process applications, and a number of new steam heating specialty items. A new "library" of descriptive literature, including 22 new catalogs, was unveiled.

Also announced was the completion of an expansion program that adds 83 per cent additional floor space to the company's manufacturing facilities.

Instantaneous Steam Water Heater

No. 3131—An all bronze, direct diffusion water heater designed to mix medium pressure steam (50 to 150 psi) with cold or warm water to provide an instant and constant supply of hot water is offered by the O'Brien Steam Specialty Co., 205 Harrison St., Syracuse 2, N. Y.



Consisting primarily of steam and water strainers, a water pressure regulating valve, a check valve, a thermostatically controlled steam valve, and a mixing chamber, the device is said to provide approximately 40 per cent more hot water per pound of steam than conventional indirect heaters. The condensate is utilized as hot water and therefore a condensate return system is not required. The manufacturer states that in the mixing chamber a new muffler type diffuser is incorporated which eliminates the excessive noise that has often accompanied the mixing of steam and cold water.

Capacities range from 600 to 5500 gph at 100 F temperature rise and standard ranges are 100-140, 120-160, 140-180, and 160-200 F. Intermediate and special ranges are also available.

THE FINEST INSURANCE

FOR HEATING AND PLUMBING SYSTEMS

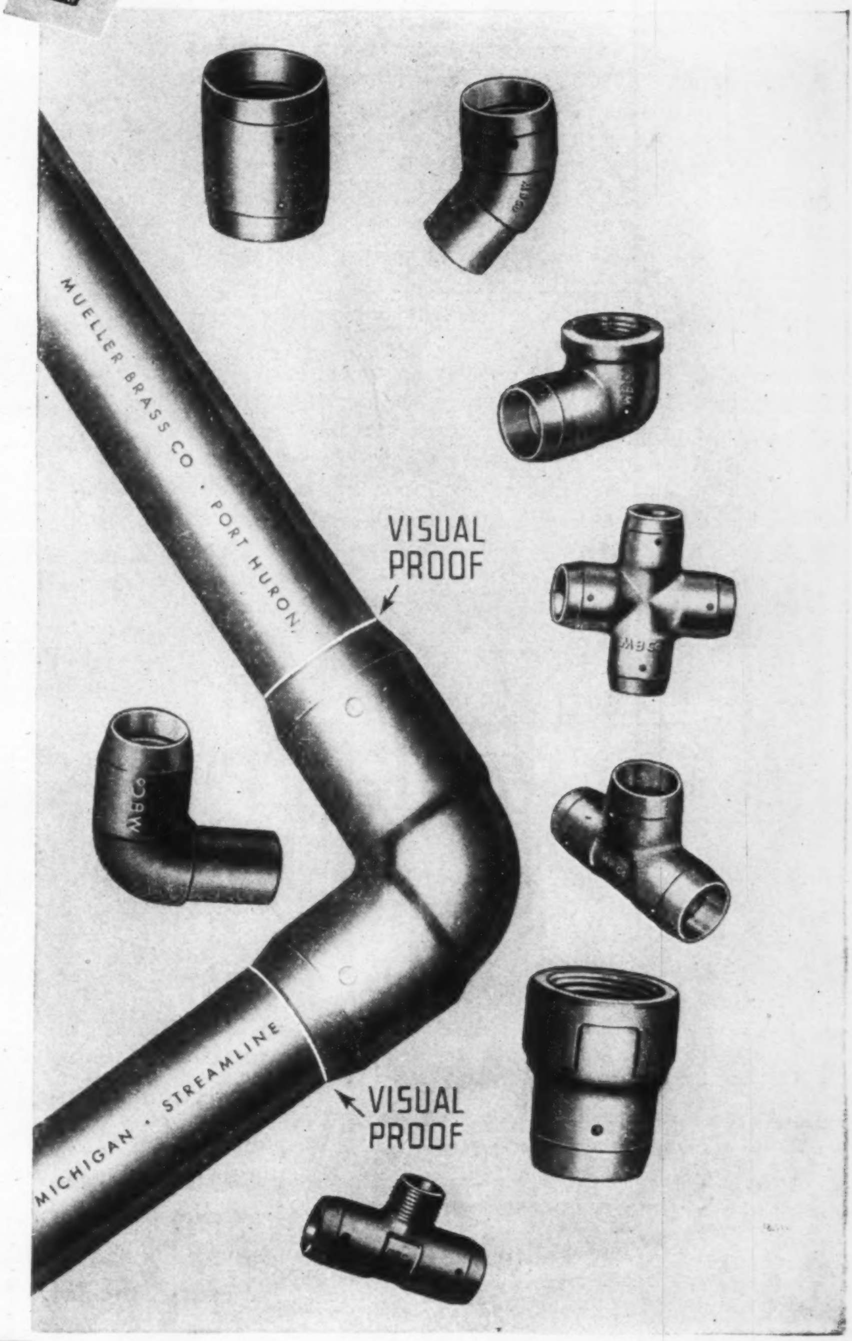
and for your own Reputation

The STREAMLINE Cast Bronze Solder Type Fitting is the only pipe fitting on the market in which POSITIVE PROOF of a leak-proof joint can actually be seen without resorting to a pressure test.

When the plumber or steamfitter makes a joint with a Cast Bronze Solder Type STREAMLINE Fitting and Copper Pipe, he does it by applying solder THROUGH THE FEED HOLE. He can tell at a glance that the joint thus made is leak-proof and permanently tight by the appearance of the solder as a complete ring around the pipe at the end of the fitting.

A SO-CALLED FILLET OR SOLDER MANUALLY MADE AROUND THE OUTER EDGE OF AN END-FED FITTING IS NOT A PROOF RING.

The plumber or steamfitter who puts in a piping system with STREAMLINE Solder Type Fittings and STREAMLINE Copper Pipe is using materials that are the most practical and handy to work with . . . no back-breaking threading and lifting . . . less equipment to carry . . . less weight and less space required. He can tell that the job is right before he leaves it. There need be no expensive "come-backs". He is building a reputation for reliability and fine work. Business grows on these assets.



STREAMLINE
TRADE MARK REG. U. S. PAT. OFF.
PIPE AND FITTINGS DIVISION
MUELLER BRASS CO.
PORT HURON, MICHIGAN

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COPPER PIPE AND FITTINGS

NEW BOOKS & REPORTS

Psychrometric Tables and Charts

Here is an entire book devoted to psychrometrics, covering the range of temperatures of —100 to 1000 F. The authors, O. T. Zimmerman* and Irvin Lavine,** have made use of the most accurate fundamental data available to calculate complete tables and plot curves. As air conditioning engineers know, the fundamental data on psychrometrics have been undergoing a continual refinement in the interest of greater accuracy. In this presentation the authors have been careful to cite the source of information used as well as to show derivation of original material.

Since some engineers prefer to work from tabular data while others prefer charts, the authors have included both. The charts, some 22 in number, are large enough for every day use.

One of the difficulties in making use of psychrometric data over the entire range from low temperature refrigeration to high temperature drying has been the necessity of becoming familiar with terminology, symbols, and datum points used by different authorities. With a single source such as this it will not be troublesome for an engineer or scientist to study the 10 pages of text and then proceed with the use of the tables and charts with confidence that he knows the basis of the data used. Repetitive use in solution of problems will make clear any strangeness in terminology that might be evident at first.

Of particular advantage to students or engineers having infrequent use of psychrometric data are a number of illustrative examples. Solutions are shown on skeletonized psychrometric charts and check solutions based on tabular data are also included.

Although most of the tables and charts are based on sea level barometric pressure of 29.921 in. of mercury, data and charts are also given to cover the pressure range of 26 to 31 in. Humidities below 32 F are calculated on the basis of vapor pressure of ice as well as vapor pressure of supercooled water, with separate tabulations. In fact, all useful data pertaining to air, water vapor, and air-water vapor mixtures are capably presented.

This is a thoroughly useful book which will undoubtedly take its place beside up to date steam tables to provide authentic basic data for engineering and scientific computations.

The text is published by Industrial Research Service, Masonic Bldg., Dover, N. H. It is cloth bound and contains 162 + vii pages ($8\frac{1}{2}$x11 in.)—116 pp of tables and 22 pp of charts. The price is $6.50. *Reviewed by Realto E. Cherne, Consulting Engineer, Rochester, N.Y.*

I-B-R Publishes Second and Third in Series of Guides

The Institute of Boiler and Radiator Manufacturers has published I-B-R Installation Guide No. 2—One pipe Steam Heating Systems and I-B-R Installation Guide

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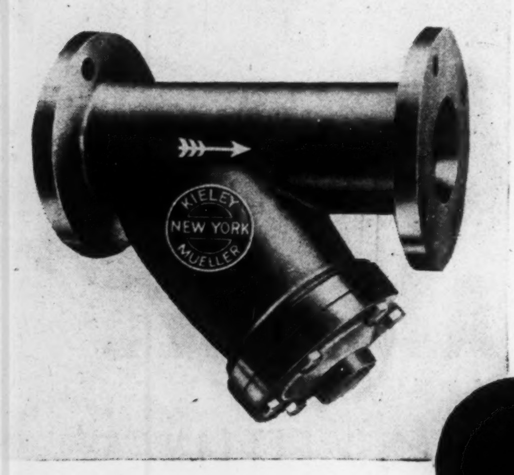
*Professor of Chemical Engineering, University of New Hampshire.

**Formerly Professor of Chemical Engineering and Head of Dept., University of North Dakota.



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—and stay away from trouble..."

A little dirt can start a lot of grief—especially to valves, pumps, traps, meters, regulators, etc. Efficient strainers installed in the inlet side of such equipment is economical protection against unnecessary wear and possible shutdowns. Kieley & Mueller make dependable strainers for every steam, gas, water, oil, air and chemical application —bodies of iron, bronze or steel, with oversize baskets of bronze, monel, stainless steel or special alloys. And always of course, the engineered superiority assured by K & M's 67-year experience—which, in strainers, means maximum filtration with minimum pressure drop

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"No More CONTACT MAINTENANCE...

I'm standardizing on Allen-Bradley Starters"

Size 2, Bulletin 709 solenoid starter with cover removed to show starter mechanism. The white interior reflects light and illuminates the starter in dark locations. Note the generous space for wiring and the easily accessible terminals.

Strange as it may seem to most maintenance men, the silver alloy contacts on Allen-Bradley solenoid starters never require maintenance of any sort. Any oxides that may form on these contacts are good electrical conductors. In addition, the extremely simple design of the solenoid starter mechanism practically eliminates the possibility of trouble. There is only one moving part—the solenoid plunger. There are no trouble-making pins, pivots, hinges, or bearings.

Allen-Bradley solenoid starters are the favorite in the refrigeration and air conditioning field, because they operate, day in and day out, without attention of any kind. Write for full information about these starting switches, Allen-Bradley Co., 1335 S. Second Street, Milwaukee 4, Wis.

ALLEN-BRADLEY
SOLENOID MOTOR CONTROLS
QUALITY

No. 3—Indirect Water Heaters. These new booklets are in addition to and supplement the first guide on one pipe forced circulation hot water heating systems.

These guides provide a basis for calculating and installing hot water and steam heating systems and are designed to stimulate the use of such systems in small and medium sized homes, according to R. E. Ferry, general manager of the institute. They have been developed as an outgrowth of the research program which the institute has sponsored for several years at the University of Illinois. Provision of maximum indoor comfort at minimum installation costs for hot water and steam heating systems has been one of the principal objectives of this research program. The guides present simple, efficient, and economical bases for calculating and designing.

Guide No. 2 on one pipe steam heating systems is for buildings having a heat loss not exceeding 92,640 Btu per hour (equal to 386 square feet of steam radiation). Three steps are recommended: they are (1) determine the radiation, (2) select the size of piping, (3) select the boiler. These steps are facilitated by the tables contained in the guide and developed for use in each step. Once the measurements of the house are determined, all other calculations may be made from the tables. Recommended installation practice for one pipe steam heating systems is discussed and points illustrated with numerous diagrams. Heat loss factors are also discussed.

Guide No. 3 deals with the domestic hot water supply furnished by indirect water heaters and outlines the details for selecting and for the more efficient installing of storage and tankless heaters. Three steps are given for storage heaters, and two steps for tankless heaters. Suggested installation diagrams are given for different type boilers (for both hot water and steam) and heaters, as well as for control arrangements with different types of fuel and firing.

Copies of the guides may be obtained from the institute headquarters at 60 East 42nd Street, New York 17, New York. The price of each guide is 25 cents in the United States.

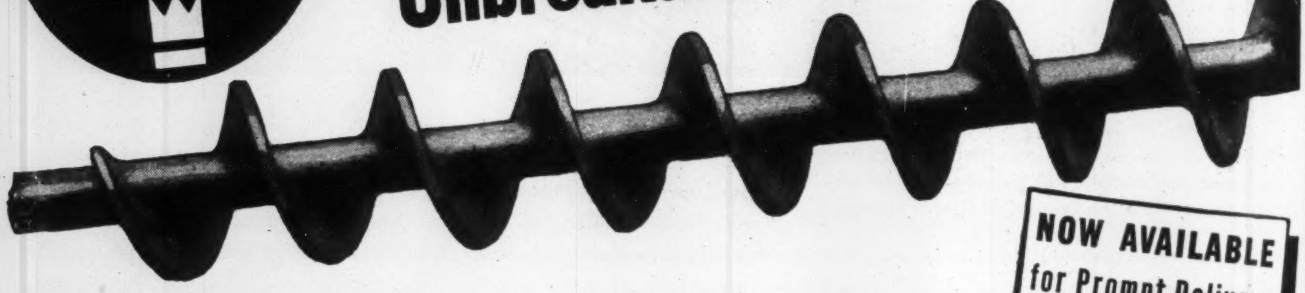
ACRMA Refrigerant Manual

Properties of Commonly Used Refrigerants, prepared by the Air Conditioning and Refrigerating Machinery Association, is a new publication which contains 97 pages of text, chart, and tabular material dealing with ammonia, methyl chloride, and "Freons 11, 12, and 22." This authoritative and comprehensive manual will be welcomed by users and installers of refrigeration and air conditioning equipment as well as by consulting engineers and architects.

Similar text material and tabulated data are included for each of the foregoing refrigerants. The text material briefly covers the physical properties, recommended working pressures, expected discharge temperatures, applications, characteristics of oil mixtures, effects of moisture, and relative pipe sizes. Data concerning the pressure, volume, temperature, heat content, and entropy are tabulated for both saturated and superheated vapors. Also included, for each of the refrigerants covered, are Mollier charts which will undoubtedly provide a means for rapid graphical analyses of refrigeration cycles. This paper covered manual may be obtained

For STOKERS

The CROWN Unbreakable Coal Feed Screw



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★ Crown's complete line of all-steel Coal Feed Screws meets every replacement and production requirement. Produced for both domestic and industrial stokers. Crown Screws are available with right or left hand screws, in all sizes and pitches, tapered or straight, and in combinations of pitches. Uniformly smooth surfaces insure that coal will flow freely and easily through the flights. Because it is all-steel with continuous weld, the Crown Coal Feed Screw guarantees long, continuous operation with full customer satisfaction. Crown is in a position to make prompt delivery on all sizes.

In ordering give complete specifications on size and design.

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1 2 3 4 FACTS ABOUT CORK

FOR LOW TEMPERATURE

Cork is one of the most useful materials known to man. Not only has it been in service longer than history can record, but its use has greatly increased with the need for modern industrial efficiency and economy. The reason for this is that Cork is completely unique in its physical structure and qualities. There's *nothing* like Cork!

For low temperature operation, here are four facts to remember:

1. **Cork is MONEY-SAVING!** Millions of dead-air cells in every square inch of Cork insulation cause it to serve as a most efficient *natural* barrier to heat flow. By its use, refrigeration is conserved to the most practical limits.

2. **Cork is LONG-LASTING!** Cork has a high degree of stability; is a most durable material. It continues to serve for many years at highest efficiency.

3. **Cork is TIME-TESTED!** The use of Cork insulation has kept pace with the development of refrigeration and cold storage. Its wide acceptance in these "heavy-duty" industries is due to its proved record for more than 40 years.

4. **Through 80 years as Cork Specialists** we are able to preserve Cork's natural advantages in Mundet insulating products. Mundet engineers offer responsible assistance in building or expanding low temperature facilities. Let us help you secure low operating cost and maximum service. Mundet Cork Corporation, Insulation Division, 65 South 11th Street, Brooklyn 11, New York.

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DETROIT 26
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CORK INSULATION

CONSERVES LOW TEMPERATURE

from association headquarters, Southern Bldg., Washington 5, D. C. The price is $1.00 postpaid.

Supplement to Book of ASTM Standards

To keep up to date its biennially published book of standards, the American Society for Testing Materials in the intervening year issues supplements to each part of the book. The 1945 Supplements to ASTM Standards, recently issued in three parts, give in their latest approved form some 230 specifications, tests, and definitions which were either issued for the first time in 1945 or revised since their appearance in the 1944 book.

Part 1 on metals contains some 395 pages, and includes over 85 standards covering ferrous and nonferrous materials. The section on ferrous metals includes steel, wrought iron, pig iron, electrodeposited coatings and also three general testing methods. Nonferrous specifications and tests include copper and copper alloy products such as tubes, strip, etc., copper and copper alloy castings, lead and lead alloys, anodic coatings, copper wire, electric furnace alloys, magnesium and its alloys, and metal powder bearings.

Part 2 on nonmetallic materials (constructional) contains 250 pages and has 50 standards. Subjects covered include filter block, glass, refractories, fire brick, thermal insulating materials, wood, paint, varnish, lacquer, etc., and thermometers.

Part 3 on nonmetallic materials (general) is the largest volume, with 500 pages and includes over 95 standards. Specifications and tests cover coal, thermometers, petroleum products and lubricants, electrical insulating materials, plastics, rubber products, shipping containers, textile materials, water for industrial uses, and industrial aromatic hydrocarbon.

Copies of these supplements can be obtained from ASTM headquarters, 1916 Race Street, Philadelphia 3, Pa., at $4.00 per part, or all three parts for $12.00. Each is bound in cloth with a back strap designed to match the 1944 Book of Standards. Heavy leather bindings are available upon the additional payment of $2.00 per part. The three 1945 supplements, plus the book of standards, give a complete set of all ASTM specifications and tests, excepting those on chemical analysis of metals which are in a special volume.

Manual on Portable Pumps

A Contractor's Pump Manual, designed to supply information on portable pumps and guidance to pump users in the construction, mining, industrial and other fields, has been published by the contractors' pump bureau of the Associated General Contractors of America.

Based on the experience of manufacturers regarding the characteristics of the several types of portable pumps, the manual discusses the selection of the proper kind and size of pump, the correct operation, maintenance, and repair.

Four types of portable pumps are presented—self-priming centrifugal, diaphragms, well-point, and road pumps. In each case the pumps are described and their particular advantages and limitations outlined. A pump selection table is included to serve as a guide in the choice of the kind of pump which can be most advantageously applied to the job to be done.

A pump trouble check sheet is included in the manual.

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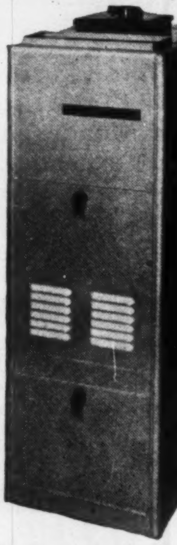

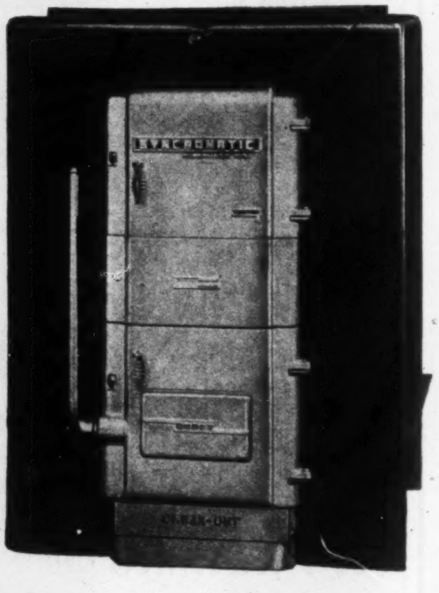

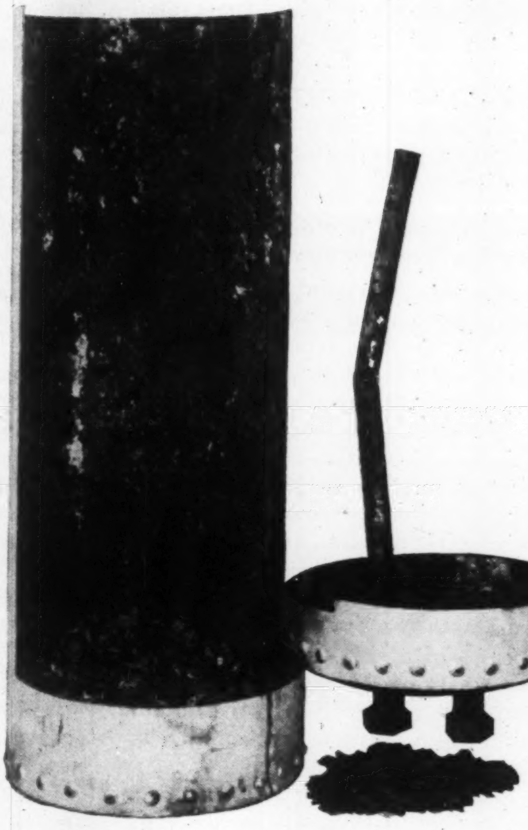

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this can't happen

where this is used ➡

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for
SCALE PREVENTION,
CORROSION CONTROL
in Water Systems
CALGON INC.
PITTSBURGH, PA.

Corrosion! Scale too, and "red water"—those thieves of your customer's plumbing and heating investment, are brought under positive control by Micromet . . . and, at an extremely low cost.

Leading manufacturers of water heaters, air-conditioning units and other water-carrying equipment are now recommending Micromet—to the lasting satisfaction of their customers—to the material reduction in their own service costs.

Micromet, a slowly soluble form of food grade glassy sodium phosphate is approved by State boards of health throughout the country. Similar treatment with glassy phosphate has proved itself in use by hundreds of cities to protect municipal water systems.

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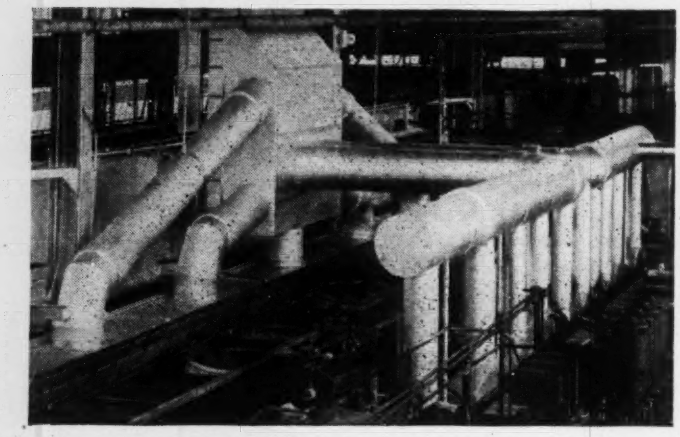
CORROSIVE
GASES? VAPORS? FUMES?



Users get more economical service from TRANSITE "S" PIPE

MANY USERS have found, in Transite "S" Pipe, a way to cut venting costs. These sturdy ducts resist many of the corrosive vapors, fumes, dusts and gases encountered in industrial operations.

Made of asbestos and cement, Transite "S" Pipe is rustproof . . . provides effective and economical venting service in a wide variety of industries.

Of course, you can use Transite "S" Pipe outdoors, as well as indoors. It is strong, durable and highly weather-resistant. It needs no painting.

Light in weight . . . easy to assemble . . . Transite "S" Pipe comes in 19 sizes—from 2" to 36" diameters—with a complete assortment of fittings for each size.

For additional information, write for Data Sheets DS Series 336. Address Johns-Manville, Box 290, New York 16, N. Y.

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Aircraft
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Dairy
Drug
Electrical
Explosive
Farm Machinery
Food
Foundry
Furnace
Furniture
Gas
Glass
Laboratory
Laundry
Leather
Match
Meat Packing
Metal
Mining
Paint
Petroleum
Potash
Pulp & Paper
Quarrying
Railroad
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Rubber
Shipbuilding
Shoe
Smelting
Soap
Soft Drink
Sugar Refining
Textile
Tool
Water & Sewage

Johns-Manville TRANSITE 'S' PIPE

together with a maintenance timetable. A list of operation Do's and Don'ts and tables of useful information such as friction charts are included.

Copies may be obtained from the Construction Foundation, Associated General Contractors of America, Munsey Bldg., Washington 4, D. C. The price is 50 cents per copy.

Relative Humidity in Packages Affected by Temperature

Influence of Temperature on Relative Humidity Within Confined Spaces With and Without a Desiccant, by Leon Lassen, is a report published, in cooperation with the University of Wisconsin, by the U. S. Department of Agriculture, Forest Products Laboratory, Madison, Wis. In his analysis of the data contained in this report (identified as R1498) the author points out that the relative humidity of a space within an impermeable barrier, without desiccant or dunnage, decreases with an increase and increases with a decrease of the temperature of the space within the barrier. In addition, the change in relative humidity is almost simultaneous with the temperature change and conditions may occur which are favorable to condensation of the confined vapor. A desiccant within a space confined by a barrier will reduce the relative humidity within the space and the magnitude of reduction is determined by the amount of desiccant used. The time required for the desiccant to establish equilibrium is dependent on the amount of desiccant, the size and shape of the package containing the desiccant, and the temperature and relative humidity of the space within the package. If the amount of desiccant used is in accordance with various specifications and formulas, safe conditions are usually established within two to three hours. The fact that relative humidity conditions within an impermeable barrier, in which a desiccant is enclosed, can be predicted with a high degree of accuracy is stressed. Based on the tests made at the laboratory, it is estimated that temperatures within a container will not exceed 165 F when exposed to the hottest shade temperature on record.

In this report special attention was given to those properties of silica gel and wood that are instrumental in the determination of the relative humidity of a package. These properties are described and then applied in numerical examples which are used to evaluate the characteristics of the desiccants. Information is given on the rates of adsorption of silica gel and the influences that determine these rates.

Microscopic Determination of Dust Particle Sizes

An 11-page, mimeographed report on the Size of Smallest Dust Particles Revealed by Various Microscopic Systems, by C. E. Brown and F. L. Feicht, has been published by the U. S. Department of Interior, Bureau of Mines, and is identified as R.I. 3821.

This report contains information on the approximate size (average diameter) of the smallest dry or unmounted silica, limestone, bituminous coal dust particles revealed by, or the limit of visibility of, various microscopic systems, some of which are commonly used in determinations on unhygienic dust collected from industrial atmospheres.

CHOOSE NAYLOR PIPE FOR VENTILATING SERVICE

There are sound reasons for the ever-increasing use of Naylor light-weight pipe in ventilating service.

This growing preference is due to practical advantages created by Naylor's exclusive Lockseam Spiralweld structure. Built in diameters ranging from 4 inches to 30 inches, Naylor Pipe is always accurate in diameter and holds its true cylindrical form during transportation, installation and service. Ends always match correctly so that the line is tight and leakproof.

Most important of all, Naylor Pipe for ventilating service can be built of lighter gauge material without any sacrifice of these performance values. The Lockseam Spiralweld creates a reinforcing truss which not only assures additional collapse strength, but also enables Naylor Pipe to be used on ventilating jobs that no other light-weight pipe can handle. The larger diameter pipe required, the more this is true.

Users report that Naylor is the one pipe they can use and re-use in ventilating service. Here again, the Naylor reinforced structure makes possible the high salvage value of this outstanding light-weight pipe.

NEW COUPLING METHOD

Along with this outstanding ventilating pipe, Naylor now offers a new low-pressure coupling known as the Naylor Wedge-Lock—a combination which provides the ideal ventilating system.

Lines can be made up quickly—faster than by any other method. A hammer is the only tool required to assemble or disassemble the joint. The coupling provides remarkable accessibility. Space on one side of the pipe only is required to connect the coupling. The compact design of this Naylor coupling permits the line to hug the wall wherever space is limited. With each joint of pipe the same length, it is a simple matter to replace any section at any time.

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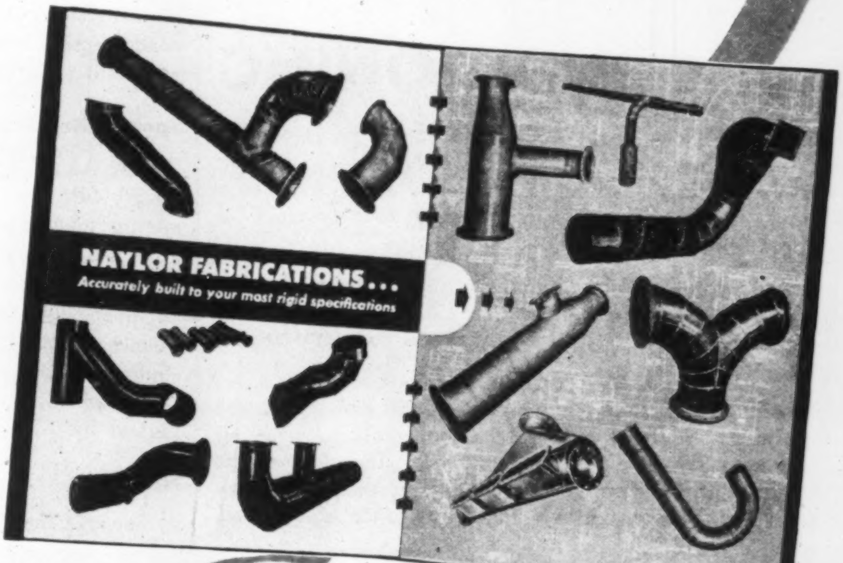

No longer is it necessary to put up with ill-fitting, inaccurate and costly pipe layouts. Naylor engineers have developed the technique and machinery for fabricating Naylor light-weight pipe to extremely close tolerances to meet your most rigid specifications. No matter how complicated the layout, Naylor "made to order" fabrications always fit the job—no adjustments are required. As a result, you can save time and labor and reduce costs through this Naylor fabrication service. It will pay you to submit specifications for quotations. Write for full details.

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General Office
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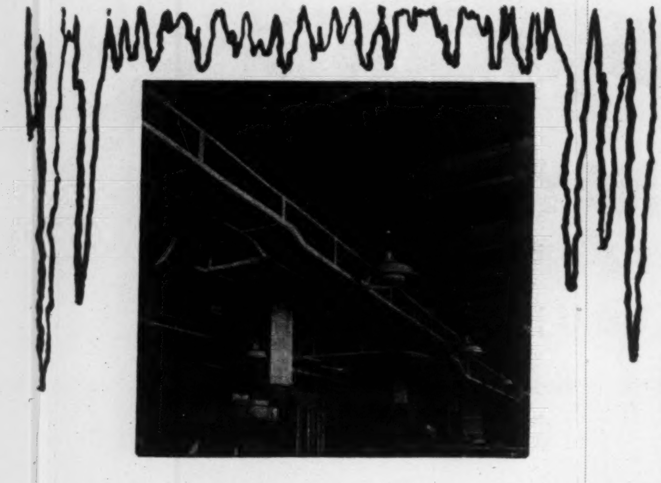

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Bare ducts are definitely wastefull—with cool air as well as warm air, in direct ratio to the temperature of the air in the area surrounding the duct work. The greater the inside and outside temperature difference, the greater the waste. Dux-Sulation corrects this waste once and for all.

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MEETINGS & CONVENTIONS

If you plan to attend a meeting soon, better check with the association concerned for any possible last-minute changes.

ACRMA to Meet May 30-June 1

The 1946 annual meeting of the Air Conditioning & Refrigerating Machinery Association, Southern Bldg., Washington 5 D. C., will be held May 30 to June 1 at The Homestead, Hot Springs, Va.

SMA to Meet June 3 and 4

The Broadmoor hotel, Colorado Springs, Colo., will be the scene of the 1946 annual meeting of the Stoker Manufacturers Association. The association, whose headquarters is at 307 N. Michigan Ave., Chicago 1, Ill., will hold a two day meeting, June 3 and 4.

Spring Meeting of ASRE in St. Paul

The American Society of Refrigerating Engineers, 40 W. 40th St., New York 18, N. Y., will hold its 33rd spring meeting at the St. Paul hotel, St. Paul, Minn., June 3-5. Two technical sessions and an air conditioning symposium have been scheduled. Among the subjects to be discussed are heat flow, microbial controls in warehouses, home freezer development, rating and testing cooling coils, conductivity of materials at low temperatures, and air conditioning problems involving the roles played by consulting engineers and contractors.

NDHA Meeting at Virginia Beach

The National District Heating Association, 827 N. Euclid Ave., Pittsburgh 6, Pa., will hold its 1946 annual meeting June 3-6 at the Cavalier, Virginia Beach, Va.

NFPA to Meet in Boston

The National Fire Protection Association, 60 Battery-March St., Boston 10, Mass., will hold its 50th anniversary meeting in Boston, June 3 to 7.

The organization, which was started by a small group of public spirited New Englanders meeting after work in a small Boston office, has grown steadily and now includes 150 national organizations and over 10,000 individuals among its members. Throughout its 50 years of growth, a prime function of the NFPA has been to provide standards for the entire field of fire control. Nearly 150 standards have been published and the association now issues from five to ten million copies of its publications a year.

ASHVE Members to Cruise on the St. Lawrence

The 1946 semi-annual meeting of the American Society of Heating and Ventilating Engineers will be held June 10 to 12. The registration, several meetings, the welcome luncheon, and a technical session will be held at the Mount Royal hotel, Montreal, Canada, during the first day of the meeting. The afternoon of June 10 members will board the cruise ship, Quebec, for a sightseeing trip up the St. Lawrence with stops at Murray Bay, Tadoussac and Quebec. During the cruise business meetings and technical sessions will be continued. The

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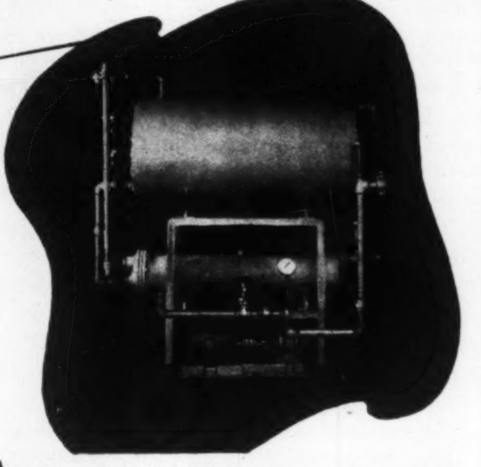
✓ **3.** With Schaub "Heat Reclaim," feed water temperatures range from 240° to 260°.

✓ **4.** Automatic boiler water level and make-up are provided for in the Schaub System.



ALL of these advantages add up to the vital fact that you can get increased steaming capacity from your boiler on the same amount of fuel—or the same amount of steam on less fuel. Either way—YOU PROFIT. A Schaub System quickly pays for itself in savings of fuel, labor and maintenance.

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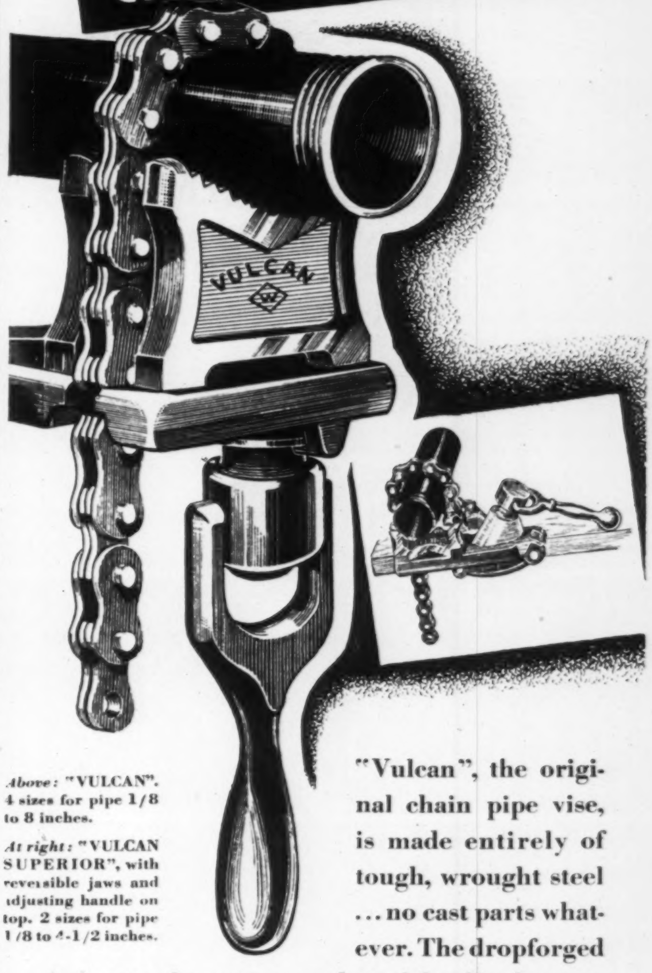

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At right: "VULCAN SUPERIOR", with reversible jaws and adjusting handle on top. 2 sizes for pipe 1/8 to 4-1/2 inches.

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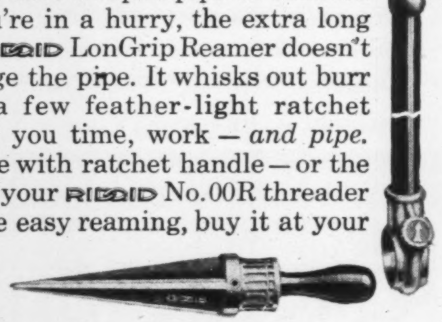
● It won't thin, flare or split pipe or conduit. Even when you're in a hurry, the extra long taper of your RIDGID LonGrip Reamer doesn't gouge or damage the pipe. It whisks out burr cleanly with a few feather-light ratchet strokes, saving you time, work — *and pipe.* Comes complete with ratchet handle — or the reamer unit fits your RIDGID No. 00R threader handle. For safe easy reaming, buy it at your Supply House.



Reamer unit fits No. 00R ratchet threader handle.

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tentative program and detailed information about the cruise are contained in the ASHVE Journal Section of this issue.

ASME Plans Three Meetings

The following meetings have been scheduled by the American Society of Mechanical Engineers, 29 W. 39th St., New York City: the semi-annual meeting in Detroit, June 12-15; the fall meeting in Boston, September 30 to October 2, and the annual meeting in New York City, December 2-6.

SPAA Members to Meet June 23-26

June 23 to 26 are the dates for the annual meeting of the Smoke Prevention Association of America. The Nicollet hotel, Minneapolis, Minn., will be the scene of the meeting and secretary-treasurer of the association is Frank A. Chambers, City Hall Square Bldg., Chicago 2, Ill.

Twenty-three Technical Sessions At ASTM Annual Meeting in Buffalo

In addition to the 23 formal technical sessions, which are a part of the technical program for the 49th Annual Meeting of the American Society for Testing Materials in Buffalo, June 24 to 28 inclusive, there will be more than 200 meetings of the society's technical committees. The 7th Exhibit of Testing Apparatus and Related Equipment will be in progress and the Annual Photographic Exhibit will also be held. All sessions will be held at the Hotel Statler.

More than 150 technical papers and reports in the field of materials are scheduled. Many of them will comprise parts of symposiums. The annual address of the retiring president will be given at the annual meeting dinner on Wednesday night, June 26, by Pres. J. R. Townsend. The guest speaker will be B. K. Sandwell, noted Canadian editor and journalist.

Application forms for hotel accommodations have been forwarded to all members and prompt execution of these forms is urged. Society headquarters is at 1916 Race St., Philadelphia 3, Pa.

NWAHACA Plans June Meeting in Chicago

The 1946 mid-year convention of the National Warm Air Heating and Air Conditioning Association, 145 Public Square, Cleveland 14, Ohio, will be held at the Edgewater Beach hotel, Chicago, June 25-26.

Construction Industries Exposition in Los Angeles

Postwar developments in construction and home building and appliances will be exhibited at the first annual Construction Industries Exposition and Home Show of Southern California July 12 to 21 at the Pan Pacific Auditorium, Los Angeles. According to M. J. Brock, president of the exposition, trade associations, contractors, and manufacturers will be among the many exhibitors. There will be nearly 200 exhibits and already more than 70 per cent of available display space has been reserved. The show is being managed by the Tabery Corp., 3443 S. Hill St., Los Angeles 7, Calif.

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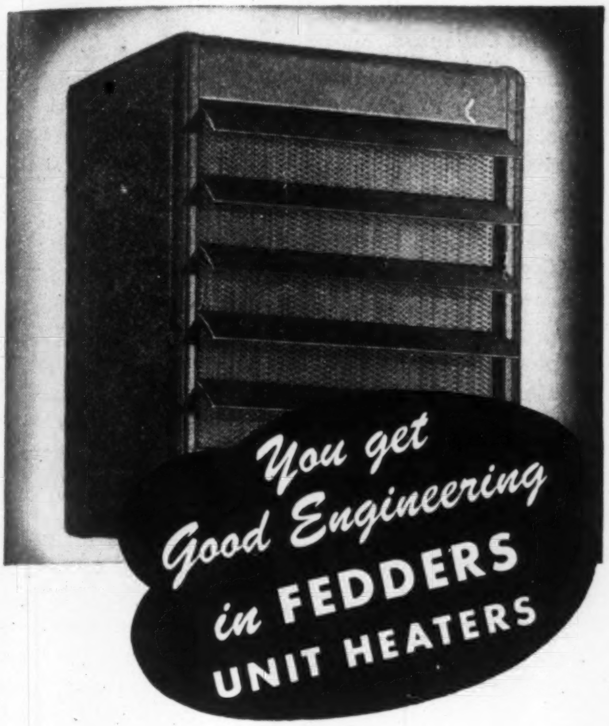

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Stream-lined copper tubes combine aerodynamic and heat transfer efficiency.

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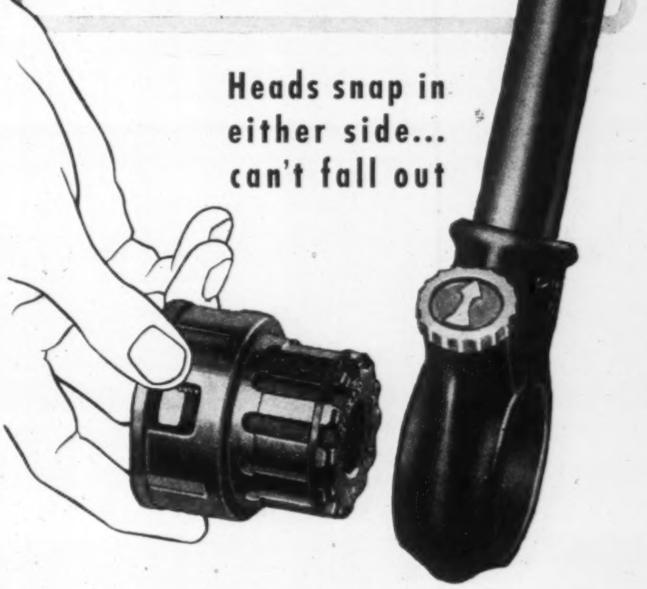
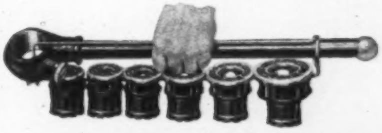


Heads snap in either side... can't fall out

• With one of these efficient and tough little steel-and-malleable threaders at hand, pipe from 1/8" to 1¼" is quickly perfectly threaded. Die heads with heat-treated tool-steel chasers snap in from either side, can't fall out. No special dies are needed for close-to-wall threads. Smooth internal ratchet. No. 00R, 1/8" to 1"; No. 111R, 1/8" to 1¼." Handy, fast, durable—try one and you understand their growing popularity. Ask your Supply House.



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REDUCTION GEAR DRIVE SHAFT

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- NO BACKLASH
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- TOTALLY ENCLOSED
- BALL BEARINGS
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A feature — reason for low maintenance in L-H Induced Draft Towers.

Case records show 4-figure savings in many multi-cell installations.

Plus low pump and power cost from L-H open flume and gravity type operations... bed-rock low-cost operation for you.

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PLANTS AT ST. LOUIS, MO., AND PLAINVIEW, TEXAS

Chemical Exposition in Chicago Coliseum

The National Chemical Exposition, sponsored by the Chicago section of the American Chemical Society, will be held September 10-14 in the Chicago Coliseum. Headquarters of the Chicago section is at 1515 S. Wabash Ave., Chicago 5, Ill.

4th All-Industry Refrigeration and Air Conditioning Exposition Scheduled

For the first time in nearly six years the mechanical refrigeration and air conditioning industry will hold a complete showing of its new products. The Cleveland Auditorium will be the scene of the 1946 Exposition which is scheduled for October 29 to November 1. The show is under the sponsorship of the Refrigeration Equipment Manufacturers' Association with the cooperation of the Frozen Food Locker Manufacturers' and Suppliers' Association. K. B. Thorndike, a director of REMA, heads the show committee. As this show is first in which the frozen food industry has actively participated, it is expected to be largest ever held by the industry as a whole. The number of displays is expected to reach at least 300. Among the six industry organizations which are planning to hold meetings during the week are The Refrigeration Equipment Wholesalers Association, The Refrigeration Service Engineers Society, the recently formed National Association of Refrigeration Contractors, and the REMA.

Show headquarters, which is also the headquarters of the REMA, is in the Clark Bldg., Pittsburgh, Pa.

AWS to Meet in Atlantic City

The 1946 annual meeting of the American Welding Society will open in New York on October 24 but will be adjourned immediately without transaction of business and will be reassembled in Atlantic City, November 17-22. The reassembled meeting will be held in conjunction with the National Metal Congress and Exposition, also to be held in Atlantic City during the same week. This will be the first five-day annual meeting held by the society since 1941.

The Ambassador hotel has been selected as AWS headquarters with technical sessions, committee meetings, and social functions being held there. The Exposition will be held in the Atlantic City Convention Hall. Society headquarters is at 33 W. 39th St., New York City.

Inspection Handbook for Manual Metal Arc Welding

This complete and authoritative manual covers the requirements and duties of a welding inspector, methods of testing welds, and contains a comprehensive description of weld inspection by visual, magnetic-particle and radiographic methods. One section of the handbook discusses the principal types of weld defects and indicates how they may be detected and corrected. The book is written in simple language and is intended to serve as a reliable source of information on any welding inspection problem. Inspection Manual for Metal Arc Welding contains 156 pages and may be obtained from the American Welding Society, 33 West 39th St., New York 18, N. Y., at $1.50 per copy.

"Cash in" on pent-up demand

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"K" PIPE FITTINGS

For years now the American public has been saving for and dreaming of new homes. The wise plumber and contractor will see to it that quality fittings are installed in those homes.

"K" fittings are high-grade, precision-built fittings. They make up fast and pull tight. Call-backs are held to a minimum, and anticipated profits are safeguarded.

"K" fittings are carried in stock at Malleable Iron Fittings Co., Branford, Conn.; M.I.F. stocks at Kuhns Bros. Co., Dayton, Ohio.

COMPLETE LINE . . . CATALOG ON REQUEST

- *Standard and extra heavy cast-iron screwed fittings.*
- *Standard flanged fittings.*
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GAS BURNERS. For use in heating boilers, power boilers—in any metal firebox or sectional boiler.

Adaptable to any firebox shape or size.

Handles various gas pressures and effects low draft loss.

The Series F600 Burner operates on straight natural gas and mixed gas to 800 B.t.u. Gives perfect horizontal distribution. Full automatic controls—that operate properly —can be easily applied. *Write for F600 Bulletin.*

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SIMPLE * COMPACT
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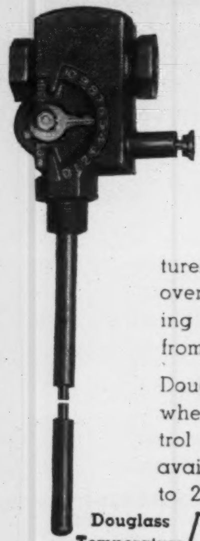

Douglass Temperature Controls are especially recommended for automatically controlling temperature of liquids in such applications as oil de-hydrators or pre-heaters, commercial water heaters, plating tanks, etc, and for atmospheric temperatures in such places as core ovens, cracker ovens, meat packing smoke rooms, paint drying rooms, etc Temperature control range from 65° to 800° F

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A Guide for Radiant Heating

No. 6150—A 75 page booklet on Copper Tube for Radiant Heating has been published by Chase Brass & Copper Co., 236 Grand St., Waterbury 91, Conn. Intended as a guide only, it is designed to provide information on the theory, broad principles, advantages, and practical problems in this method of heating. The booklet contains virtually the same information as that contained in the Radiant Heating Manual recently issued by this company except for the technical discussions and illustrations pertaining to the selection and sizing of radiant panels. Additional information concerning practical problems has been added in this booklet.

Air Conditioning for The Textile Industry

No. 6151—The Carrier Corp., 302 S. Geddes St., Syracuse 1, N. Y., has issued a 40 page nontechnical booklet, one of a series of 36 new catalogs, which describes six air conditioning systems which can be adapt-

BOILER FEED UNIT

"E" Award for high achievement in the production of Condensate Return Units.

- For use where boiler feed should be controlled by boiler water level.
- Where operation of boiler water make-up condensate return is combined.
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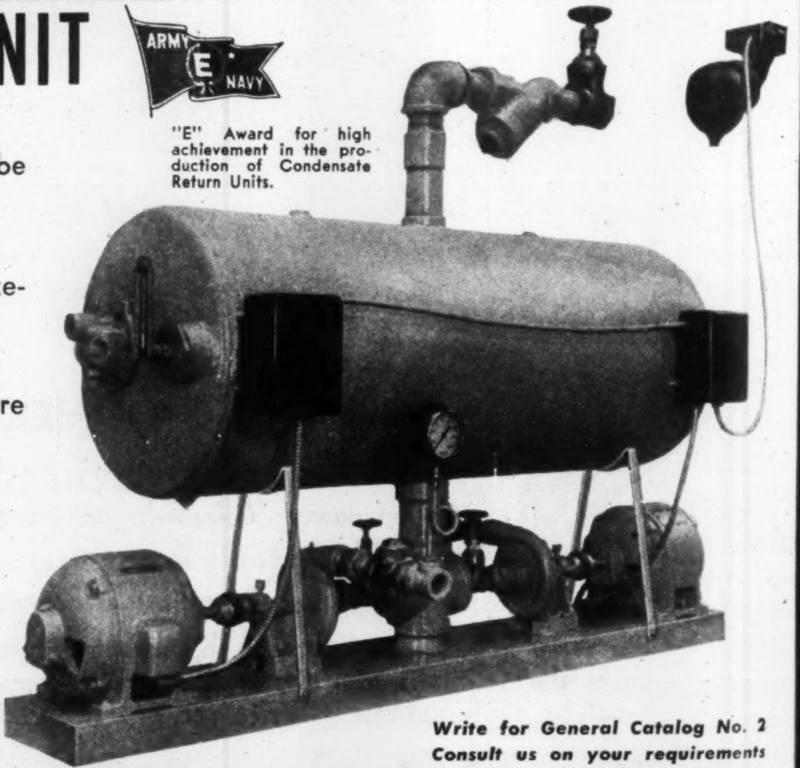

This is one of the various types of Condensate Return Units manufactured by Walter H. Eagan Co. No matter what your requirements, there is an Eagan Unit to do the job.

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Consult us on your requirements

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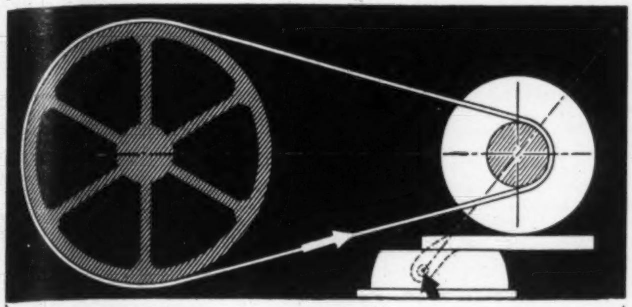
TESTED RELIABILITY FOR YEARS OF CONTINUOUS SERVICE



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with Little Attention or Expense

TANNATE flat leather belt
has a very high coefficient of friction and great pliability that helps keep machines running at top speed. It is treated to resist moisture, oil and weak acids, TANNATE has unusually high tensile strength which contributes toward increased service life and reduced maintenance expense.

ROCKWOOD motor base
one or both pulleys and the belt are supplied by Rhoads. Designed to work together, they give superior performance. Maximum speed is maintained and driven machine capacity is increased when TANNATE-ROCKWOOD flat belt units are put on your drives. Get the most efficient and economical drives for your machines. Ask for further details.

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For more than a quarter of a century Acme products have been engineered and built to operate as a unit for co-ordinated performance in larger size refrigeration and air conditioning systems.

There is, naturally, an advantage in efficiency of operation when the major component parts of a system are all built in the same factory—designed by the same group of engineers and fabricated by the same skilled, experienced workers.

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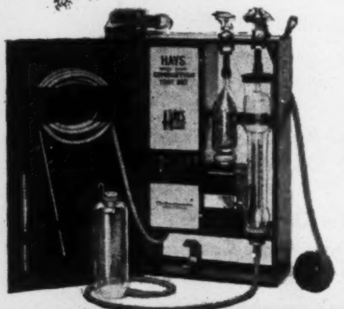
Money going up the flue?

MAKE YOUR OWN CO_2 TEST



You can get an accurate CO_2 reading in 30 seconds—and in 3 or 4 minutes a complete analysis including draft and flue gas temperature, by this handy, accurate Hays Combustion Test Set.

Reveals efficiency of combustion—tells how much money is going up the flue.

A new booklet "ABC of CO_2" is important reading—permits you to figure actual fuel loss. Write for it.

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ed to the needs of individual textile mills. The importance of comfort conditioning in this industry is also stressed. Among the advantages of air conditioning for process work, which are mentioned, are uniformity and quality of goods, reduction of soilage through elimination of airborne dirt by filters, and elimination of the need for frequent process machine adjustments because of weather variations.

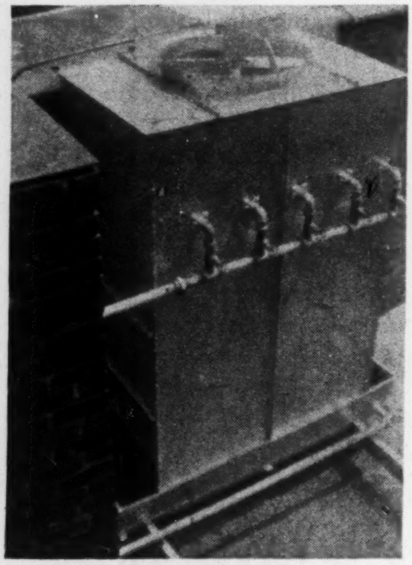
Circulating Pumps and Venturi Fittings for Hot Water Heating

No. 6152—A new data sheet (No. 32-WW-45), issued by Taco Heaters, Inc., 342 Madison Ave., New York City, carries information on two types of circulating pumps for hot water heating systems. A rating table and two installation diagrams are included. A hook up diagram and a condensed design table supplement a description of the "Taco-One" venturi system for one pipe hot water heating.

Continuous Boiler Blowdown Valves

No. 6153—A 4 page catalog (No. 102) together with 4 pages of supplementary information and a sizing check chart describe and illustrate the "Evrtyte" valve manufactured by Strong, Carlisle & Hammond Co., 1392 W. Third St., Cleveland 13, Ohio. The valve is recommended for continuous boiler blowdown, throttling, water column blowdown, boiler sampling, and hydraulic service and is said to be suitable for use with soot blowers and numerous instruments. It is designed for pressures up to 1500 psi and temperatures up to 800 F. For

TRAY COOLING TOWERS



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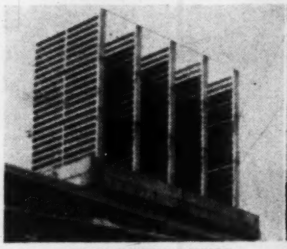
SAVE 98% of CONDENSER WATER COSTS wasted thru REFRIGERATION and AIR CONDITIONING PLANTS



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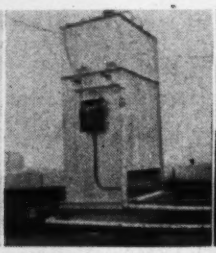

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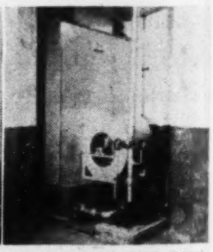

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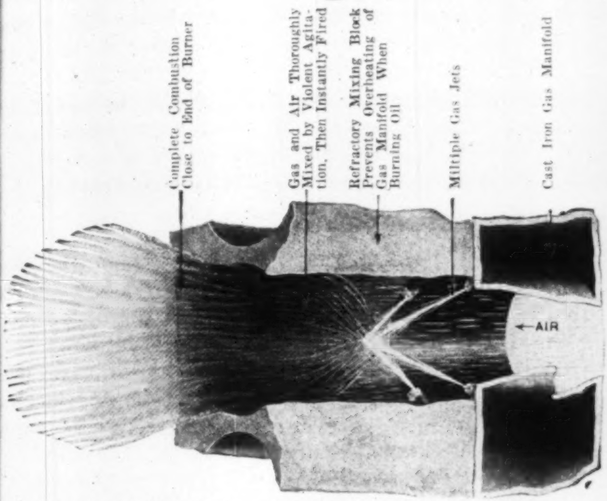
The Mettler ENTRAINED COMBUSTION Gas Burners

REG. U.S. PAT. OFF.
EXPERTO CREDE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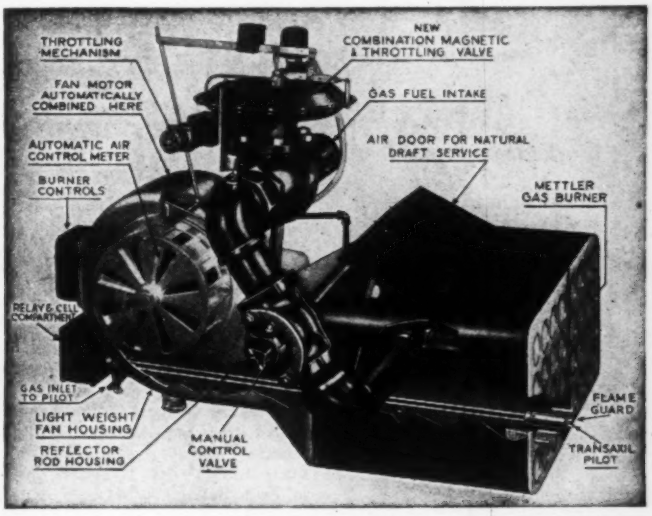
Gas and Air Thoroughly Mixed by Violent Agitation, Then Instantly Fired
Refractory Mixing Block Prevents Overheating of Gas Manifold When Burning Oil
Multiple Gas Jets
Cast Iron Gas Manifold
AIR

This section thru a Mettler Gas Burner Manifold shows how it "mixes" gas and air. It's *easy* to see why it's still the best.


THROTTLING MECHANISM
FAN MOTOR AUTOMATICALLY COMBINED HERE
AUTOMATIC AIR CONTROL METER
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NEW COMBINATION MAGNETIC & THROTTLING VALVE
GAS FUEL INTAKE
AIR DOOR FOR NATURAL DRAFT SERVICE
METTLER GAS BURNER
FLAME GUARD
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The "Fan-Air Gas Burner" in adjoining picture embodies this leading patented casting design with all the other essential and desirable features of this *Fully Assembled Mechanical Draft Automatic Gas Burner.* It comes to you complete as pictured, representing the modern day burner. Why be satisfied with less—when all these tangible advantages are so readily available in sizes 5 to 400 HP.?

SIZES 5 TO 400 HP. **PROMPT SHIPMENTS**

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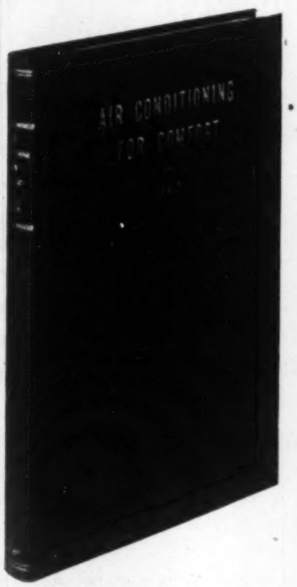
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by SAMUEL R. LEWIS

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AUTO-VENT AIR ELIMINATORS

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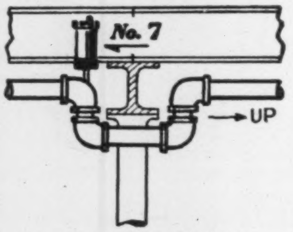
Don't fight air pockets or traps in hot or cold circulating lines. "Get that air out of there" *and keep it out* simply by installing the No. 7 Maid-O'-Mist Automatic Air Vent. This reliable air vent has a self-closing float-controlled valve and is designed especially for circulating pipe lines, convector radiators, unit heaters, cooling manifolds, tanks, diesel engines, or any other application where air pockets or traps retard the free circulation of liquids. Now available in bright brass finish. For pressures up to 75 pounds.



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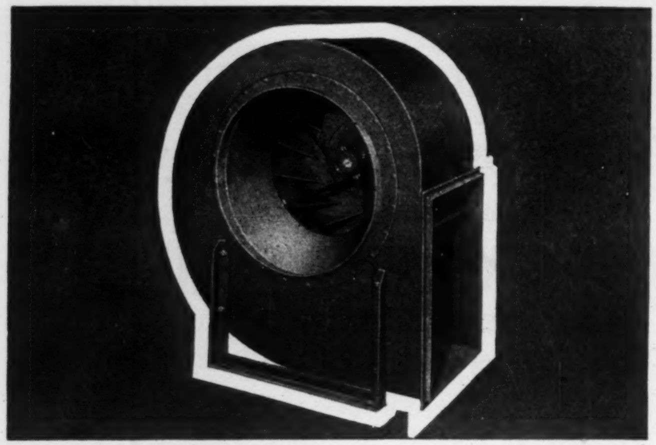

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nonshock cold service it is suitable for pressures up t 6000 psi.

Copper Alloy Welding

No. 6154—A 32 page booklet on materials and procedures for welding and brazing copper and copper alloys has been issued by C. E. Phillips & Co., 2750 Poplar St., Detroit 8, Mich. Definitions of materials and processes, data on compositions and properties, and suggestions for the design of welded joints and the use of jigs and fixtures are included. Many of the common copper alloys are discussed individually and also covered are the company's line of welding rods and electrodes.

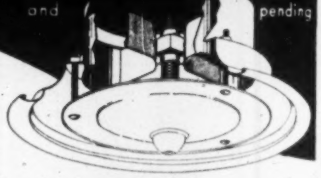
Direct Fired Space Heater

No. 6155—Production methods used in manufacturing the company's line of direct fired space heaters are featured in Vol. 1—No. 1 of Dravo Slant, the house organ of the Dravo Corp., Machinery Div., 300 Penn Ave., Pittsburgh 2, Pa. These heaters are designed to burn coal, gas, or oil and, in the four pass gas and oil fired types, are available with outputs ranging from 300,000 to 1,650,000 Btu per hr.

Electrodes for High Tensile Steels

No. 6156—Vol. 7, No. 1 of Welding Briefs, the house organ of the Metal & Thermit Corp., 120 Broadway, New York City, includes a description of the company's line of "Murex" chrome-moly electrodes which were developed primarily for power piping and similar work. Tabulated data pertaining to physical characteristic

Cut installation time in half with adjustable air diffusers



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IN CANADA:

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and chemical composition are included.

Electronics in Industry

No. 6157—A 28 page, illustrated booklet (No. A-4726), The Business Man's Guide to Electronics, has been issued by Westinghouse Electric Corp., Bloomfield, N. J. The booklet is designed to show how electronics are being used extensively in industry. Among the many applications described are induction and dielectric heating for tin plating and brazing, electronic control for welding electronic regulators for mixing and packaging, power conversion in mills and factories, safety devices using photoelectric tubes, and measuring with such devices as the mass spectrometer, etc.

Filters

No. 6158—The "Refiner," a pressure leaf type filter for clarifying and polishing is described and illustrated in an 8 page pamphlet issued by Blackburn-Smith Mfg. Co., River St., Hoboken, N. J. The unit is said to break the tightest emulson in condensate and to remove all emulsified and free oil from an oil content as high as 90 ppm down to a guaranteed maximum of 0.01 ppm. The company's standard filter for removing mechanically suspended foreign matter from liquids such as make up water for boilers and process water for industrial use is also described.

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No. 6159—The "No-Thread" fitting, consisting of a malleable iron sleeve, enclosing two pipe ends, and two threaded nuts which compress a rubber compound gas-

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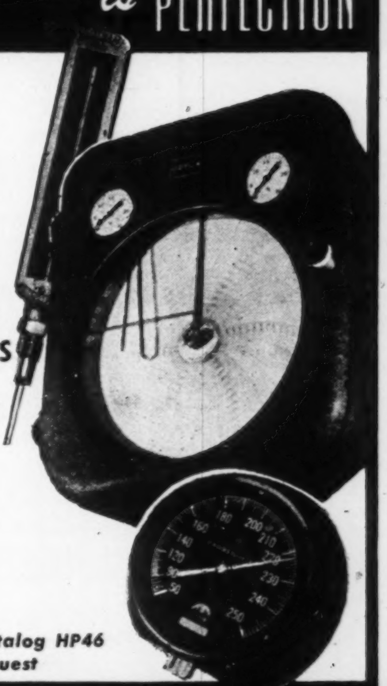
Indicating, Recording and Controlling Thermometers, Pressure Gauges and Controllers for every Industrial Application



Illustrated catalog HP46 on request

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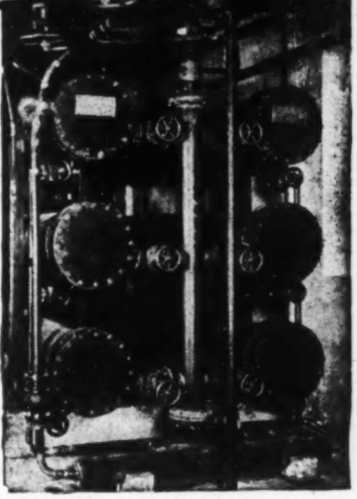

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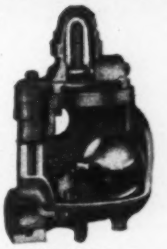
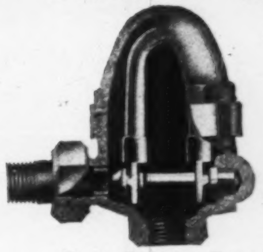


F & T Trap



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Accurate performance is a byword when you install Haines Traps. The Float and Thermostatic Traps are designed for any low pressure job up to 20 lbs. in the ¾" size and 30 lbs. in the 1" and 1¼" sizes; they cannot become air bound, and the Haines underslung valve principle assures safety—no danger of building up a pressure.

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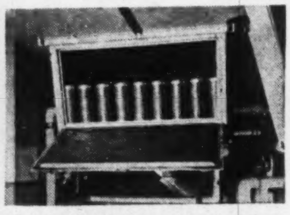

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All ventilation is essentially the dilution of stale, odorous and contaminated air. Fresh air for that purpose can be obtained by purifying already conditioned return air with Dorex *activated carbon* Air Recovery Equipment. This can be done at a cost materially lower than the cost of drawing in and conditioning the quantities of outdoor air otherwise required.

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ALL MARTOCELLO SPRAY NOZZLES are manufactured with precision and of a design which has been thoroughly tested for maximum results and durability. They are guaranteed to give satisfaction. Successful, efficient results depend largely upon selecting the proper number, type and size of Nozzles suitable for your installation.

THE MARTOCELLO CONDENSER WATER DISTRIBUTORS are now used as standard equipment by Progressive Refrigerating Engineers in solving their Manpower problem, because they require no attention and assure users of the lowest Condenser Operating Pressures and Minimum Power Cost.

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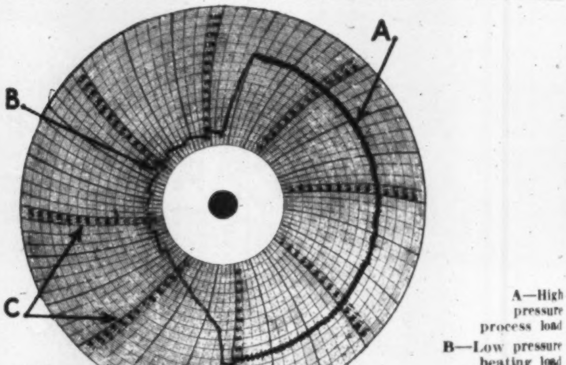
ket around the end of each pipe, is described and illustrated in a 16 page catalog (No. 418B) issued by Dresser Mfg. Div., Dresser Industries, Inc., 490 Fisher Ave., Bradford, Pa. Standard fittings, which are available in sizes from ⅜ to 2 in., are said to be suitable for use on pipe lines carrying oil, air, gas, water, low pressure steam, gasoline, and many chemical products.

Fuel Units for Oil Burners and Variable Speed Control for Blowers

No. 6160—Webster Electric Co., S. W. Corner Clark & De Koven Aves., Racine, Wis., has issued a catalog containing a number of bulletins which illustrate and describe the company's line of fuel units for oil burners. These include single and two stage pumps, regulating valves and strainers, ignition transformers, and special replacement fuel units designed to fit a number of well known oil burners now used extensively. Several bulletins are included which cover the "Thermodrive," a variable diameter pulley for use on blowers in forced warm air heating and air conditioning systems. The diameter is varied by means of thermostatic bellows.

Heating, Ventilating and Air Conditioning

No. 6161—A discussion of coil selection for run-around reheating in air conditioning systems is featured in the March issue of Weather Magic, the house organ of the Trane Co., La Crosse, Wis. In this system warm air is first passed through a precooling coil. The water, which has been warmed by the air, is used to reheat the air from the dehumidifier coil. Also men-



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ASK ANY BOILER OWNER what he considers the prime requirement of any steam boiler. His answer will be: *"Uniform steam pressure."*

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NOT ONLY THAT . . . York-Shipley backs the product with a distribution plan which utilizes local distributors, whose engineering staffs *size and install* the job . . . and keep it in trim year after year.

STEAM-PAK GENERATOR

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YORK-SHIPLEY INCORPORATED
America's Most Complete Line—Industrial, Commercial, Domestic Oil-Burning Equipment
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tioned are installations of the company's heating equipment and other products in a motor bus terminal, a boys' military school, offices, and industrial plants.

How to Control Radiant Heating

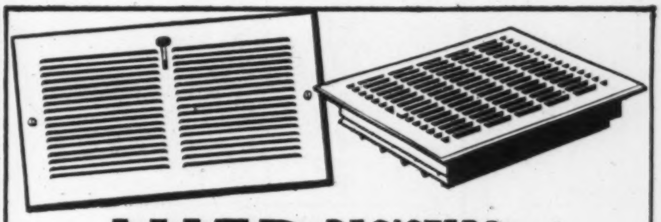
No. 6162—A 20 page booklet, How to Control Radiant Heating, has just been published by the Johnson Service Co., 507 E. Michigan St., Milwaukee 2, Wis.

After briefly describing the various types of radiant heating systems, which are commonly used, the booklet stresses the control problem caused by the inherent thermal inertia of the system. This is especially pronounced where coils are embedded in slabs of concrete. To anticipate heating demands and to reduce wide temperature fluctuations, it is recommended that the primary control of radiant systems be based on changes in outdoor temperature. It is pointed out that when the primary control is based on changes in outdoor temperature, the interval of time between the addition of hot water to the panel coils and time the panel is actually warmer, is, to some extent, matched by the time lag which occurs between the time the weather temperature drops and the time this effect is transmitted through the building structure.

For closer control of space temperature, more elaborate control systems using room thermostats as secondary controls are discussed.

Instantaneous Water Heater

No. 6163—Capacity and dimension tables, which are



AUER REGISTERS *and* GRILLES

Shown above are Auer "7000" Airo-Flex adjustable-fin type wall register, and also the DuraBilt cross-bar, interlocked construction, floor register. Below are shown a few typical Auer stamped metal grilles. Auer offers dealers and contractors a most complete line of registers and intakes for modern warm air and for air conditioned systems, and grilles for all purposes. Featuring adjustable and air directional models, as well as new style gravity types—Auer can supply ALL your register needs economically. Auer Registers are stocked by leading jobbers. Write for complete Auer Register Book—or Grille Catalog "G".

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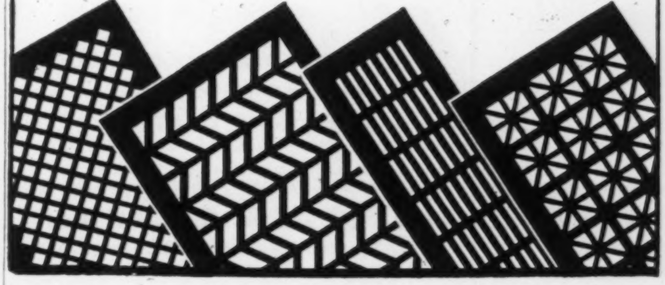

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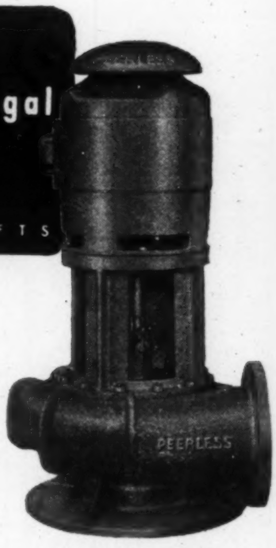
Vertical Centrifugal
Pumps
FOR SHALLOW LIFTS



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100 to 5000 g. p. m.
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• Peerless Vertical Centrifugal Pumps are intended for general pumping purposes. • They are built in both the Close-Coupled and Submerged types. The Submerged type is furnished with either top or bottom suction. Direct connected electric motor, steam turbine or engine drive, either direct or through right angle gear. • These pumps are successfully applied to sumps or drainage or wherever it is necessary to move large quantities of water at comparatively low lift. • Installation space is reduced to a minimum, of paramount importance in industrial installations... Extremely economical to operate.

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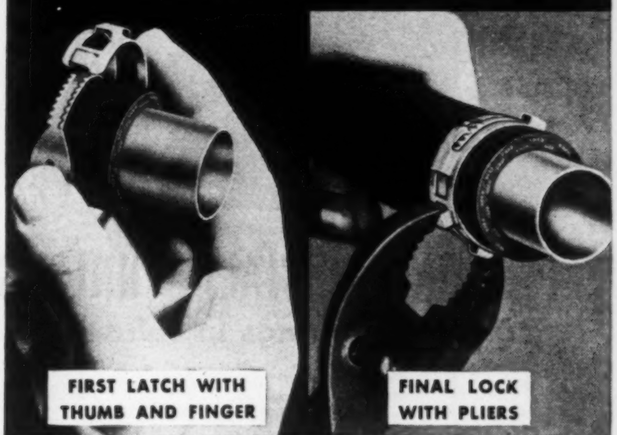

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"Rydlyme" for successful scale removal.

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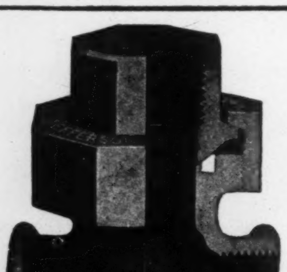

JEFFERSON SPECIALTY UNIONS

Effect Big Savings in Labor

Jefferson Union Tees with union on the outlet assure labor savings and better piping jobs because they take the place of an all-female union, two nipples and an ordinary tee. Three joints are thus saved. Available in All-Female and Male and Female threads.

The brass seating in these and all Jefferson Specialty Unions is an exclusive feature which, located in a recess away from the runway of the fitting, leaves a straight bore assuring unrestricted flow in the pipe.

JEFFERSON UNION CO.
601 West 26th Street, New York 1, N. Y.

Factories at
Lexington 73, Mass. Lockport, N. Y.

augmented by diagrams of typical hookups and other pertinent information, are contained in a new data sheet (No. 18-T-45) on tankless water heaters issued by Taco Heaters, Inc., 342 Madison Ave., New York City. Available in four standard sizes, these heaters are pressure-tested for 300 psi in coil and 60 psi in the shell. Pressure drop is approximately 10 psi at 180 F rating.

Nickel Alloy Steels

No. 6164—A new valve steel for impact strength at low temperatures, developed by the Crane Co., and a high Ni-Cr steel alloy suitable for boiler descaling operations, developed by Worthington Pump and Machinery Corp. and the Lebanon Steel Foundry, are among the numerous products and applications of nickel steel alloys which are described in the March issue of Nickel Steel Topics, the house organ of the International Nickel Co., 67 Wall St., New York 5, N. Y.

Oil Burner Ignition Insulator

No. 6165—Bulletin No. 745, describing the use of "AlSiMag 42" for oil burner ignition insulators, has been released by the American Lava Corp., Chattanooga 5, Tenn. The electrical and mechanical characteristics of this material are covered as well as the various standard and special sizes which are available. The insulators, which are approved by the Underwriter's Laboratories, are designed for use with electrode assemblies employing transformers rated at 12,000 volts secondary, or with transformer secondary assemblies rated at 15,000 volts with the center tap grounded. Other type insulators with a higher puncture rating are available.

Janette
Blower
Wheels

5 to 12 in.

These Illustrations Show the **Patented Construction of a Janette** Wheel. The blades are formed in pairs for rigidity. The blade slots in the steel discs are die cut to ensure exact spacing of the blades. The hub is riveted to the back plate; then the blades are inserted into the slots. After the blades are spot welded to the back plate the tips are pressed thru the slots of the inlet disc, then rolled down against the disc.

The Inherent Spring of the Blades Keeps Them Tight.

Because of This Construction, Janette Wheels have given over **19 years of universal satisfaction** to internationally known manufacturers of coal stokers, blowers, ventilating equipment, air cooled engines, oil burners, superchargers,, dust collectors, drying and fire detection apparatus. **It Will Pay You to Give Janette Blower Wheels a Trial**

May We Send Literature?

Janette Manufacturing Company
556 W. Monroe St. Chicago 6, Ill.

Overhead Blower Units

No. 6166—Overhead blower units for low temperature cooling are described and illustrated in a new 12 page catalog (No. 110) issued by the Rempe Co., 362 N. Sacramento Blvd., Chicago 12, Ill. Recommendations regarding air velocities and sizing of units are included. Units are available for use with sulphur dioxide, methyl chloride, "Freon," anti-freeze solutions, ammonia and brine.

Propeller Type Fan Blades

No. 6167—The Torrington Mfg. Co., 70 Franklin St., Torrington, Conn., has issued a catalog covering the company's line of propeller type fan blades. Specifications and performance data on two new 24 in. fans in the 4 blade "Standard" design are among the 134 fans (ranging from 3 to 48 in. in dia.) listed. Both NEMA and NAFM performance ratings are given.

Protective Coatings

No. 6168—Organic Protective Coatings and Their Performance on Electrolytic Tinplates is the subject of a folder published by Watson-Standard Co., 225 Galveston Ave., Pittsburgh, Pa. Prepared by C. H. Groff and I. R. Messer, the folder outlines variables which affect properties and performance of electrolytic tinplates. Tables and charts of various tests are included.

Small Solenoid Valve

No. 6169—Sectional drawings, mounting diagrams, and other detailed information are included in a bulletin covering the "V5-100" solenoid valve manufactured by Allied Control Valve Co., Inc., South Norwalk, Conn.

NEW POST WAR ENGINEERING

The Hartzell fan line for 1946 is completely new — a result of twenty years of air-movement experience and four years of intensive engineering research. So improved is air-delivery per power dollar that a new age in air-movement is established. Free air delivery is definitely stepped up. Efficiency is carried twice as far up the pressure scale, in many sizes. Certified air delivery tables in our new Bulletin 1102 prove these facts; the same bulletin describes the new Hartzell propeller-and-ring combination which makes them possible. Bulletin 1102 is free. Send for it today.

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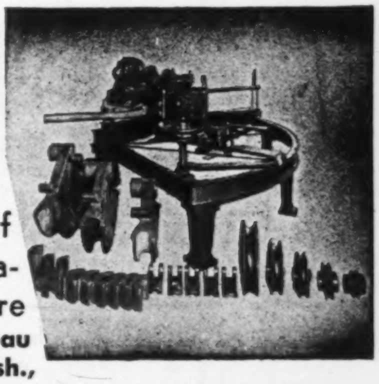
PIQUA DIV. OF CASTLE HILLS CORP. **OHIO**
ENGINEERING REPRESENTATIVES IN PRINCIPAL CITIES

COLD PIPE, CONDUIT and TUBE BENDING MACHINES

12 types from which to select; hand operated capacities:- ¼ to 6" inclusive; motor operated:- ½ to 8" inclusive. Now indispensable to contractors, shipbuilders, ordnance plants and thousands of others. These machines are essential also in industrial conversion.



12,000 customers — and more—can testify to the indispensability of "American" machines. Here are a few users: Bureau of Ships, Wash., D. C.; Henry J. Kaiser Co., Calif.; Pacific Bridge Co.; Bethlehem-Hingham Shipyards; Hercules Powder Co.; Stone & Webster; E. I. Du Pont de Nemours & Co.; Crane Co.

"American" PIPE BENDING MACHINE Company INC
Quick Deliveries
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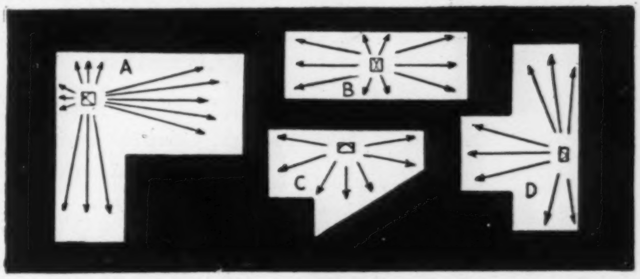

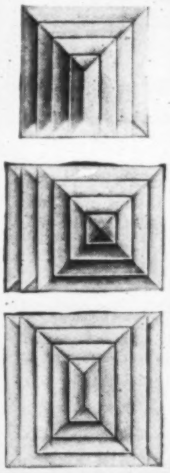

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FOR DIFFUSION PATTERN CONTROL

Perfect diffusion of air into all parts of odd-shaped rooms is available only with Agitair Type R Air Diffusers. And you don't need to mount type R in the center of the space.

That's because Agitair Type R, assembled from standard parts to any pattern desired, can divide the incoming air into one, two, three, or four streams, and diffuse these streams into the room in exact proportion to the areas they serve. Temperature differential and duct velocity are dissipated rapidly, noiselessly, draftlessly. Get the facts from Air Devices, Inc.

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Just snap in a latching SPEED NUT

A PRESS OF THE THUMB SNAPS LATCHING TYPE SPEED NUT SECURELY IN PLACE
SPEED NUTS eliminate handling of material

A SPEED NUT CASE HISTORY

A truck manufacturer used a battery of machines to clinch nuts in place for assembly of instuments to dash and dash to cowl. Two men were at each machine . . . to handle the large stampings and position them. This handling meant frequent damage to stampings, and after painting, nut threads had to be retapped.

30 self-retaining Speed Nuts are now snapped in place by hand on each stamping as it moves from the press department on conveyers. The entire assembly is completed in much less time, machines eliminated and costs substantially reduced.

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MORE THAN 3000 SHAPES AND SIZES

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Stainless Steel Bellows

No. 6170—The use of stainless steel bellows as equalizers, compensators, expansion joints, flexible connectors, and in valves, vapor and steam traps, thermostatic instruments and other industrial applications is described and illustrated in a new 12 page booklet (No. SSB-46) issued by Chicago Metal Hose Corp., Maywood, Ill. Specification charts and other pertinent data are included.

Steam Traps, Humidifiers And Refrigeration Purgers

No. 6171—Tips on installing steam type humidifiers are featured in the No. 1, 1946, issue of the house organ published by Armstrong Machine Works, 874 Maple St., Three Rivers, Mich. Installations of other products, such as steam traps and purgers for noncondensable gases in refrigeration systems, are described and illustrated.

Sun Ray Direction Finder

No. 6172—The "Solarmeter," used for finding the direction of sun rays at any hour of the day, is described and illustrated in an 8 page pamphlet issued by R. W. Justice, Box 122-D, Belvedere, Marin County, Calif. The device may be used to orient wings, walls, glass areas, etc., and may also be used to modify heating and cooling load calculations for parts of buildings affected by solar heat.

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De Luxe type WK Pressure Actuated Water Regulating Valves for Freon, Sulphur or Methyl, are pilot operated, modulating. Standard adjustable opening range from 50 to 150 lbs. Factory set to open at 90 pounds. Precision engineering and individual testing for low cost, satisfactory performance. Available in sizes of ¾ to 2 inches FPT. Simple adjustment—easily serviced.

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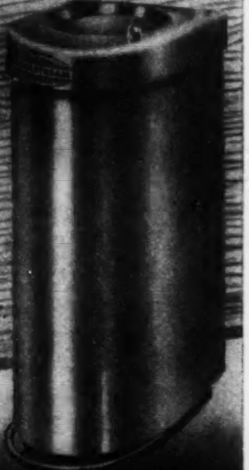

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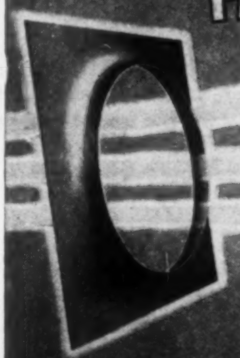

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These sections are formed cold . . . dimensions are uniform.

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NOW-PIPE JOINT COMPOUND in Stick Form

NO LEAKS!
Just rub 3 or 4 strokes across pipe threads. It spreads and fills threads when turned.

FOR ALL THOSE PIPE INSTALLATION AND REPAIR JOBS

Always Ready For Instant Use

ECONOMICAL
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Tested and Fully Approved by Independent Laboratories and Industry.

NO MESS
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- ★ Contains no lead. Contains no injurious ingredients.

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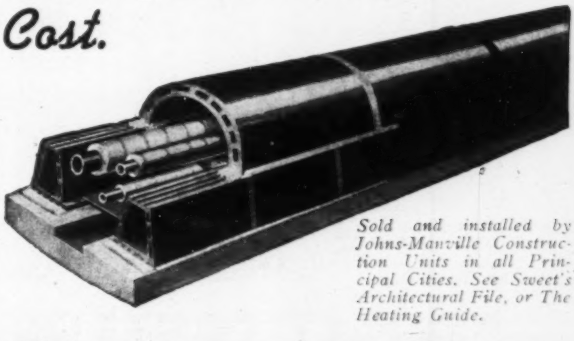

Sold and installed by Johns-Manville Construction Units in all Principal Cities. See Sweet's Architectural File, or The Heating Guide.

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☐ Enclosed is a sketch of a prospective underground pipe.
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Eliminate Costly Shut-Downs From Leaky Water Lines *by using* **KEY-TITE**

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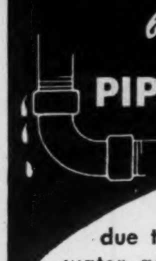

Key-Tite Pipe Joint Compound will eliminate shut-downs due to faulty connections on lines carrying water, gas, low-pressure steam, etc.

Key-Tite is economical to use because it goes several times as far as ordinary pipe dopes. Joints sealed with it will *not* leak again, yet, can be easily opened because this compound will not freeze the connections. Key-Tite does not settle in the can and always retains its plastic qualities and full body — it contains no lead nor lead substitutes and will not affect the taste or odor of potable liquids.

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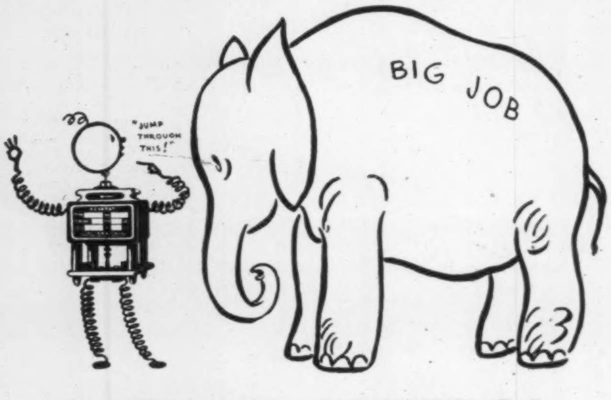

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Suppliers of Nickel Alloy Parts Listed

No. 6173—The International Nickel Co., 67 Wall S New York 5, N. Y., has published a 44 page bookle How to Find Long Life, which lists the suppliers o "Inco" nickel alloy parts and accessory equipmen Listed are 188 separate items, ranging from speci tower packing to nonsparking safety tools, and th name and address of each manufacturer is given.

Testing and Rating Convectors

No. 6174—In the March issue of the house orga published by the Modine Mfg. Co., 1772 Racine St Racine, Wis., the history and development of variou methods used for rating convectors and radiators, t gether with a discussion of the adoption of EDR ra ings, serve as an introduction to a short summary o the work which has been done by the Convector Join Code Committee in preparing a proposed commerci standard for testing and rating convectors.

Thermometers and Hydrometers

No. 6175—The Gotham Instrument Co., 149 Wooste St., New York 12, N. Y., has issued a new catalo (No. C-51) covering the company's line of etched ste thermometers and hydrometers. A number of types o thermometers are offered in various temperature range between —70 and 950 F. According to the manufa turer, all hydrometers meet API scale requirements an other standards. They are designed for many specif uses.

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It will cost you nothing to ask us for a quotation on your requirements.

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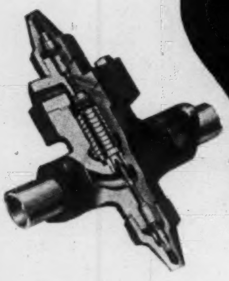

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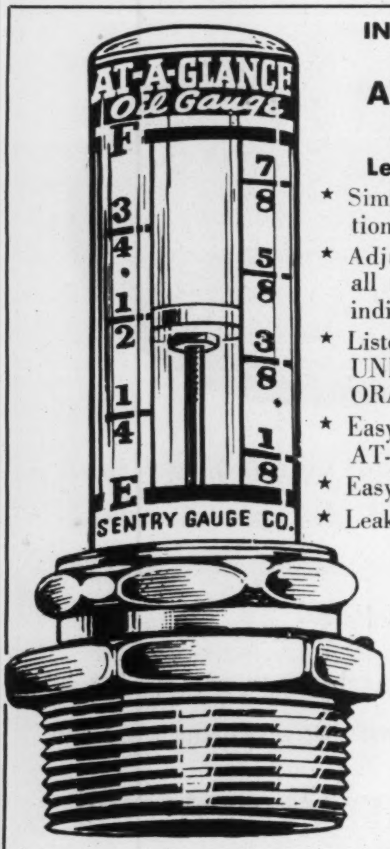

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Tube Cleaner For Gas Mains

No. 6176—A unique method, developed by a west coast gas company, for replacing worn out gas mains is described in the 1946 Spring issue of "Powerfax," the house organ of the Elliott Co., Jeannette, Pa. The method consists of attaching an air-driven motor, with suitable cutting head, to copper tubing. The cutter and tubing are pushed through the old pipe and the smaller diameter tubing is connected to the gas system as a permanent installation. The method is said to eliminate much digging.

Underwater Cutting and Welding

No. 6177—Metal and Thermit Corp., 120 Broadway, New York City, has issued a 10 page booklet on underwater cutting and welding. The arc-oxygen process for cutting steel under water and for cutting cast iron and high alloy steels in the open air is described and considerable working data and procedure information are given. In addition "Murex" electrodes for welding and cutting light gage materials under water are covered.

Valves and Fittings

No. 6178—Manufacturing procedure and the various phases of production used in making malleable iron unions and union fittings, together with a description of the company's line of standard iron body wedge gate valves are contained in the Vol. 6, No. 5, issue of the Walworth Co., 60 E. 42nd St., New York 17, N. Y. house organ. Valves of the nonrising stem type and the outside screw and yoke type in both all iron and bronze mounted design are discussed.

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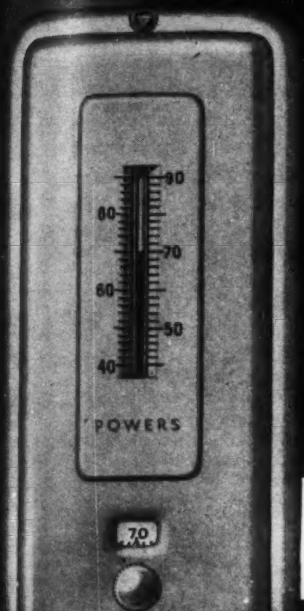
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has been an outstanding feature of Powers regulation since 1891. With this type of control, valves or dampers are opened or closed **gradually**, which results in exceedingly close regulation and the maximum of comfort obtainable with automatic control.

● **THE POWERS REGULATOR CO., 2759 Greenview Avenue, CHICAGO. Offices in 47 Cities. See your phone book.** 43

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Using Rutland Pipe Joint Cement saves a lot of cleaning up afterwards. It does not stain hands or fixtures. Also, Rutland seals joints tightly and lasts indefinitely —but always leaves pipes easy to disjoin. Remains soft in can.

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TUBE MASTER

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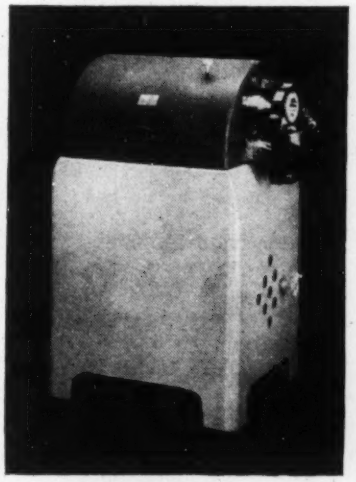

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